ELECTRIC POWER RESEARCH INSTITUTE

EPRI Assessment of Potential Worker Dose Impacts from More Restrictive Dose Limits

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Radiation Management Program Drivers and Goals

- Regulatory Drivers (NRC):
  - 10 CFR 20 and 10 CFR 50, Appendix I Update to Align with ICRP 103 Recommendations

Most Significant Change: Reduction in Individual Dose Limits

- Industry Performance Drivers (INPO):
  - New INPO cumulative radiation exposure (CRE) dose goals (cycle median) by the end of 2015:
    - PWR: 55 person-Rem
    - BWR: 110 person-Rem
  - Eliminate/Reduce High Radiation Areas
  - Reduce Contaminated Areas
    - Reduce Personal Contamination Events (PCEs)

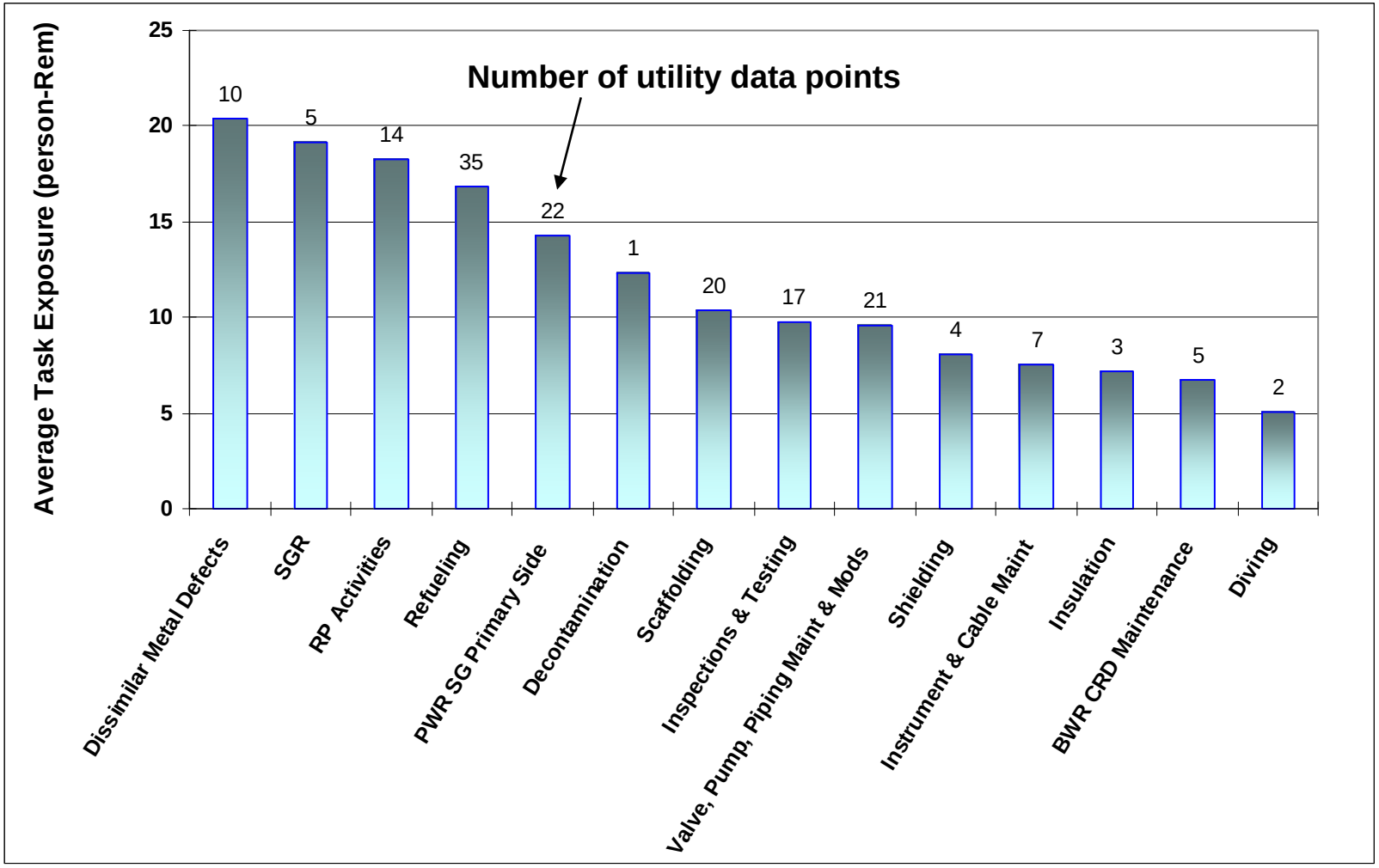
Radiation Management Program Drivers and Goals (continued)

- EPRI Radiation Management Program Goals:
  - Primary Goal
    - Provide tools, technologies, and techniques to reduce individual dose and cumulative dose:
      - All workers < 2 rem/yr by 2015
      - All workers < 1.5 rem/yr by 2020
  - Secondary GoalS
    - Reduce High Radiation Areas
    - Reduce Contaminated Areas

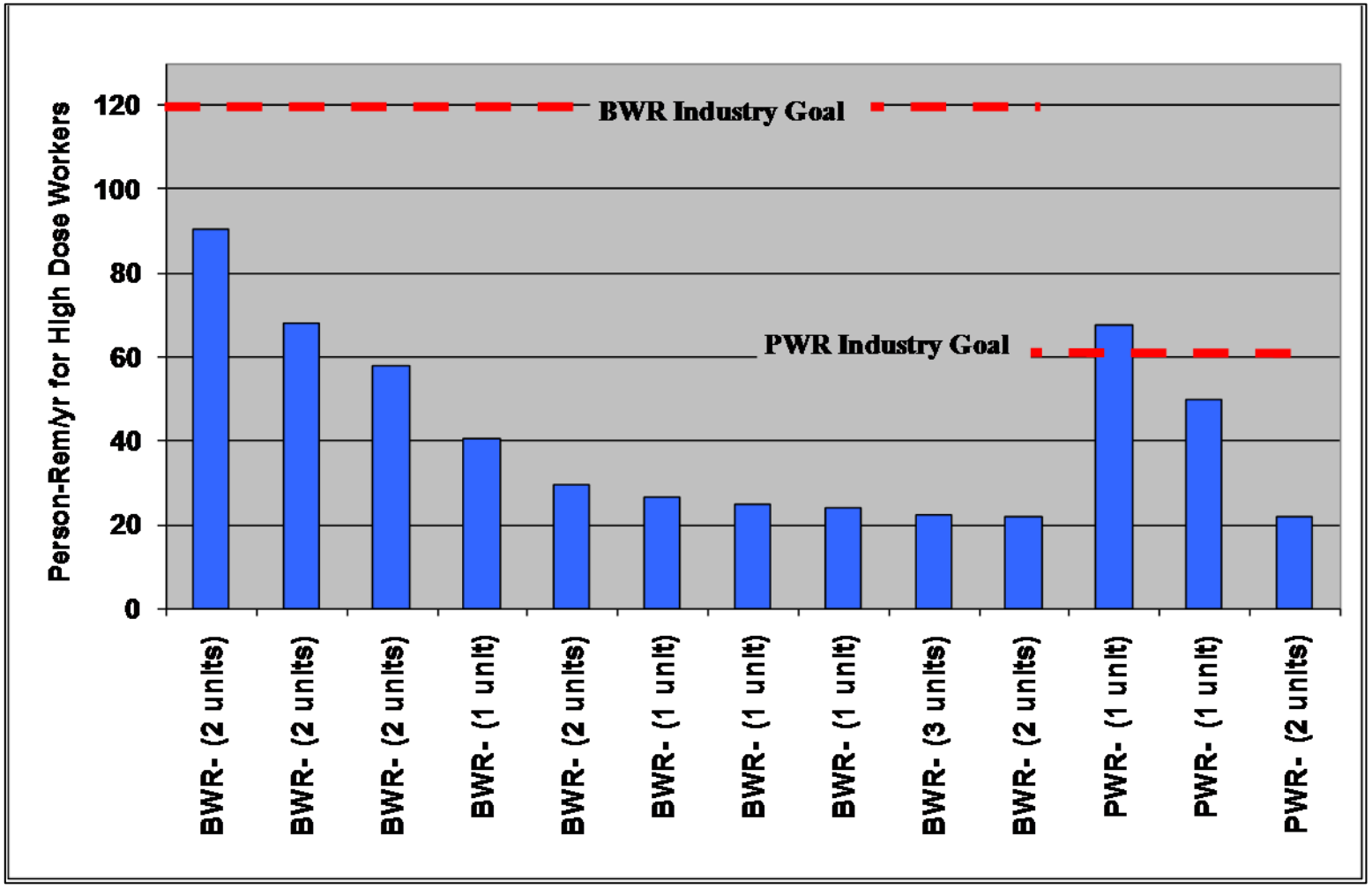
Approach

- Data
  - Industry cumulative task/ exposure data from **34 BWR and PWR sites**
  - Individual dose data from PADS was evaluated
    - **27 PWRs and 13 BWRs**
    - Task type, worker trade/profession, reactor site
- Identify tasks with highest impact on collective and individual radiation exposure
- Information from other data sources was evaluated
  - INPO, NRC, NEI and industry owners groups
  - MRP, BWR/VIP, NDE and SG maintenance
- Technologies were evaluated
  - In development and commercially available
  - Reduce exposure related to specific tasks or evolutions
  - Identify gaps where improved or alternate technology is warranted
  - ID opportunities for field application
- **Input and technical support from 49 peers and other industry experts**

Average Task Exposure for High Dose Tasks
(Utility Data)



Cumulative Dose Analysis –
Person-Rem per Year for High Dose Workers (PADS Data)



Workers that received >500 millirem per site visit

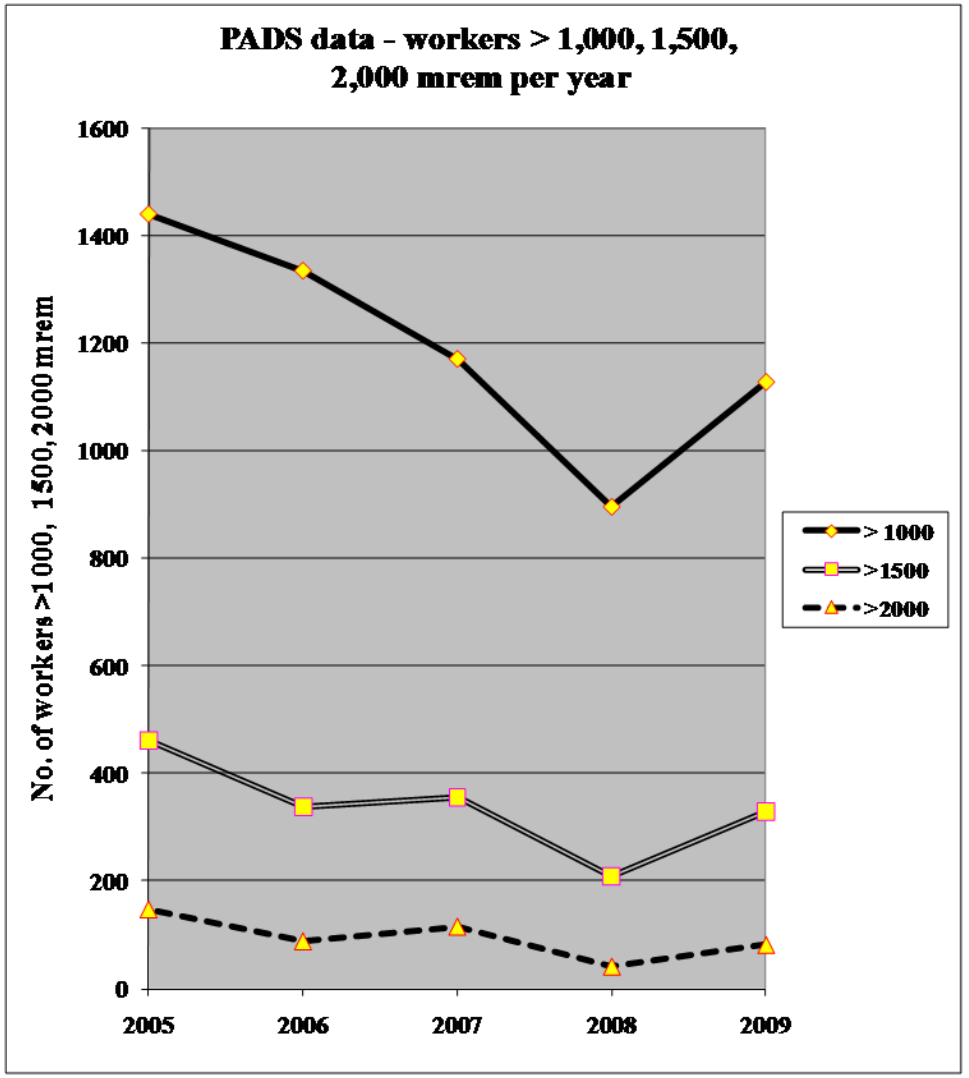
Cumulative Dose Analysis – The Affect

- Significant fraction of the industry per-reactor per-year goal is attributable to high dose workers
  - Note that 2 reactor dose is site total (previous slide)
- 2 single unit PWRs in the 50-60 person rem / year range
  - Industry PWR target = 55 person rem per year

Individual Dose Analysis –
Workers Exceeding 1, 1.5, and 2 Rem per Year

- 2009 Data
- 104 operating reactors
- 81 individuals > 2 rem
- 328 individuals > 1.5 rem
- 1126 individuals > 1.0 rem

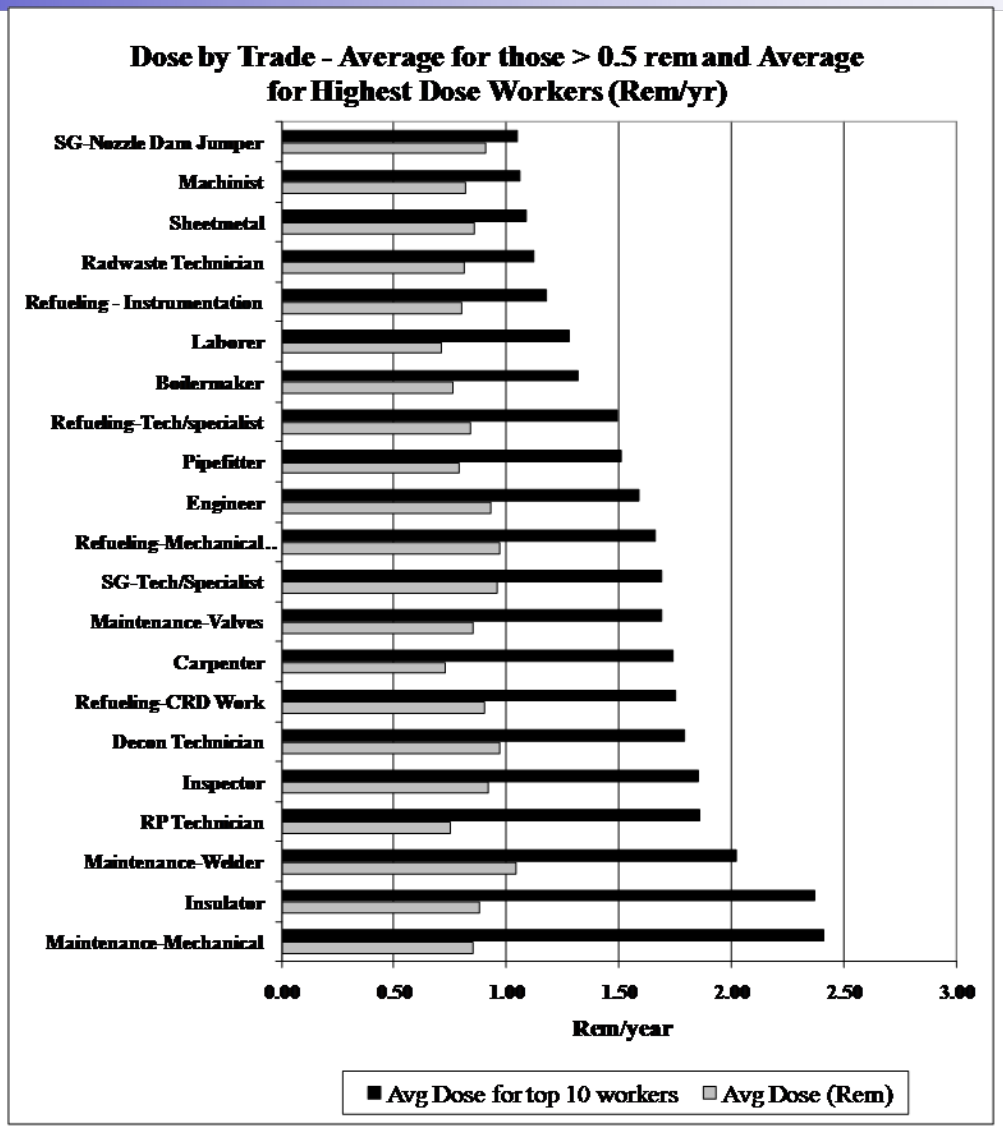
- 1535 workers > 1.0 Rem



Individual Dose Analysis -
Highest Average Dose per Worker (for > 1 rem workers)

Task	Average Dose per person (millirem)
Inspections	1,522
Decontamination	1,479
Radiation Protection	1,450
Valve maintenance	1,440
Pump Maintenance	1,430
Insulation	1,430
CRD exchange	1,420
Dissimilar Metals Project - Repair/replacement	1,392
Major Projects	1,371
Refueling - Reactor head lift and replacement	1,365
Refueling - Reactor head studs	1,336
SG Nozzle dam installation & removal	1,335
SG Eddy current testing	1,333
Refueling - Undervessel activities - instrumentation	1,317

Individual Dose Analysis -
Dose by Trade - for Workers > 0.5 Rem



Individual Dose Analysis – The Affect

- Highest dose plants challenged to meet 2 rem per year
- Administrative limit = 1 rem per year?
- Several hundred individuals who are receiving over 500 mrem per visit
- Spring outages will severely affect skill set availability for remainder of the year
- Exacerbates current staffing challenges

Task Analysis – Utility Outage Reports

Priority Ranking	Primary Task, Component, or Evolution	Specific Task(s)	Contributor to Individual Dose of > 1 person-Rem Annually			Recurring (R) or Infrequent (I)	Causal Factor(s)
			In single outage or for single task	Same person, multiple outages	Not Normally		
1	Refueling	PWR and BWR reactor head stud removal and replacement – close proximity to reactor head for several workers to detension, remove, replace and re-tension studs. Equipment may be air, electric, or hydraulic or a combination of one or more of those.		X		R	•Technology - stuck or galled threading on studs. •Inadequate shielding on reactor head. •Rigging – failures of hoist used for shielding and/or stud handling. •Tensioning tooling failure. •Inadequate cavity decon after draindown. •Workers proximity and time relative to head or cavity debris source term. • Worker inexperience.

Solutions: Technology Evaluation

- **Activity Removal from Liquid: Underwater Demineralizer System**
  - Used in BWRs, one PWR design, 2011 target technology
- **Activity Removal from Liquid: Isotope Selective Media**
  - Tested in 2010 by RSI, works as designed, required media structure mod.
- **Activity Removal from Surfaces: DeconGelTM Capture Decontamination**
  - Has not been applied to full cavity, long cure time
- **Activity Removal from Surfaces: Hydrogen Peroxide**
  - Used at several stations, specific components (e.g., JAF), some cavity decon
- **Activity Removal from Surfaces: ElectroDecon™ Chemical Decontamination**
  - Has not been applied to full cavity, viable, but appears to be labor intensive for large surfaces
- **Communication: Frontline Communicator**
  - Deployed, viable solution
- **Communication: Vocera System**
  - Deployed, viable solution

Solutions: Technology Evaluation (cont.)

- **Radiation Shield System: Charging Method for Tungsten Balls**
  - Deployed in 5 Japanese reactors, demonstration planning in progress for 2011 at Calvert Cliffs site
- **Radiation Survey Technology: RadBall**
  - Viable technology, recent advances in sensitivity (99% improvement), evaluating demonstration at a Duke site in 2011
- **Component Removal and Installation: Hydraulic Nuts (HydraNuts)**
  - Deployed at many reactors, 2010 application at Quad Cities, 2011 planned deployment at Comanche Peak
- **Surface Pretreatment: Hi-F Coat Surface Treatment**
  - Deployed at one Japanese reactor, in-situ decon and coating, merits investigation in 2011 & 2012

Solutions: Technology Evaluation (cont.)

- **Human Performance/ Error Reduction: Interactive Virtual Reality**
  - Not developed for nuclear, would provide significant benefit, very high initial investment, merits continued observation
- **Vertical Access: Modular Bridge**
  - Deployed at Nine Mile Point, simple solution, local fabrication, custom design by application
- **Vertical Access: X-Deck**
  - Deployed at several reactors, simple solution, replaces scaffolding up to 6’ in height
- **Work Control Planning and Scheduling, Modification Design: Laser Scanning**
  - Deployed at very large number of reactors worldwide as an engineering tool, excellent tool for work control and ALARA planning, estimating, shielding and scaffolding
  - Integral part of EPRI 3D-EDE Algorithm and ALARA Planning Tool development project

Solutions: Technology Application

Primary Task, Component, or Evolution	Specific Task(s)	Causal Factor(s)	Candidate Technology	Candidate Host Site
Refueling	PWR and BWR reactor head stud removal and replacement	Technology - stuck studs.	HydraNuts	Comanche Peak
		Inadequate shielding.	Charging Method for Tungsten Balls	
		Rigging – failures of hoist used for shielding and/or stud handling.		
		Tensioning tooling failure.	HydraNuts	Comanche Peak

Summary and Conclusions

- Challenges to meet lower individual and collective dose targets.
- In terms of specific repetitive jobs, refueling and PWR steam generator eddy current testing were high in both individual and collective dose.
- Insulators, carpenters (scaffolding), welders, radiation protection technicians, inspection personnel, and decontamination workers were the highest for individual and collective dose.
- Refueling is recommended as a major repetitive task that merits further evaluation.
  - Other tasks with higher collective dose
  - **Refueling has high individual dose, high collective dose, repetitive, and highly skilled workers**
  - Refueling is almost always on critical path
  - Improvements in technology or efficiency from a dose reduction aspect will likely result in decreased critical path time

Summary and Conclusions (cont.)

- Three specific technologies targeted that may reduce refuelling dose:
  - Tri Nuclear underwater ion exchanger for **PWR** cavities
    - Used in BWRs, one PWR design available
  - GE HGNE's Hi-F decon and coating process
    - Successfully implemented in Japan at Shimane Unit
    - Process involves decon (Potassium Permanganate, Oxalic Acid, Hydrazine) followed by Hi-F Treatment
  - GE Hitachi's BWR CRD vortex flush
    - New concept, developed at Dresden
    - Adapt to PWR head configurations?

2011 - Refueling Activity Dose Reduction

- Working Group
  - Utilities, EPRI, INPO, refueling vendors, technology suppliers
- BWR and PWR host site
- Identify specific causal factors
  - Fields
  - Source
  - Activities
  - Options
- Technology Applications
  - Traditional including shielding, remote, etc.
  - Three specific technologies on previous slide
- Standardization of Dose and Activity Tracking
  - For specific tasks

2010 Report Information

- **EPRI Report # 1021100; “Assessment of Potential Worker Dose Impacts to Radiation Protection Programs Due to Recommendations in ICRP -103, and Evaluation of Nuclear Industry High Dose Jobs and Technologies”**

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