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Dose Reduction Options for Refueling Tasks
EPRI Report: 1025309

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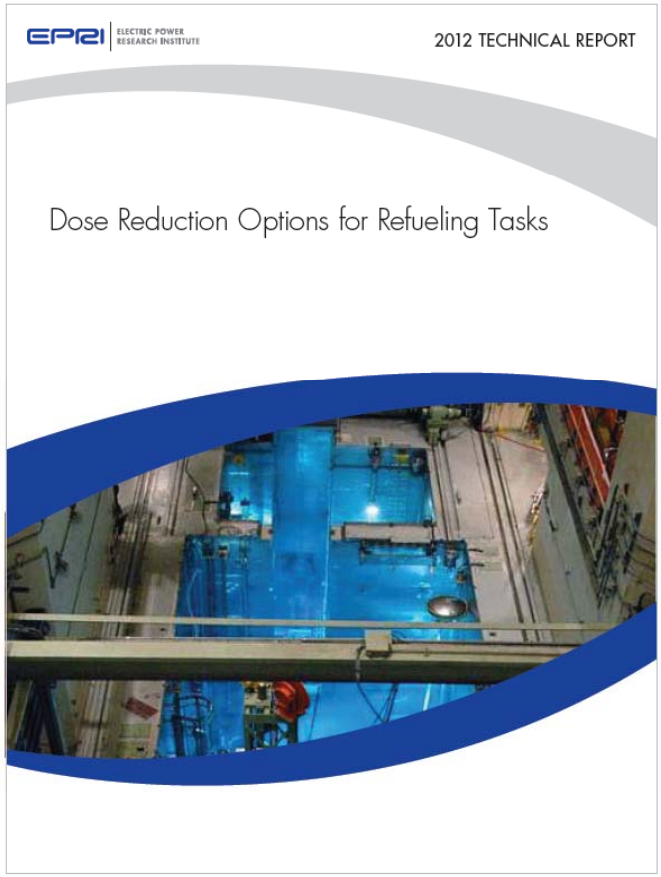

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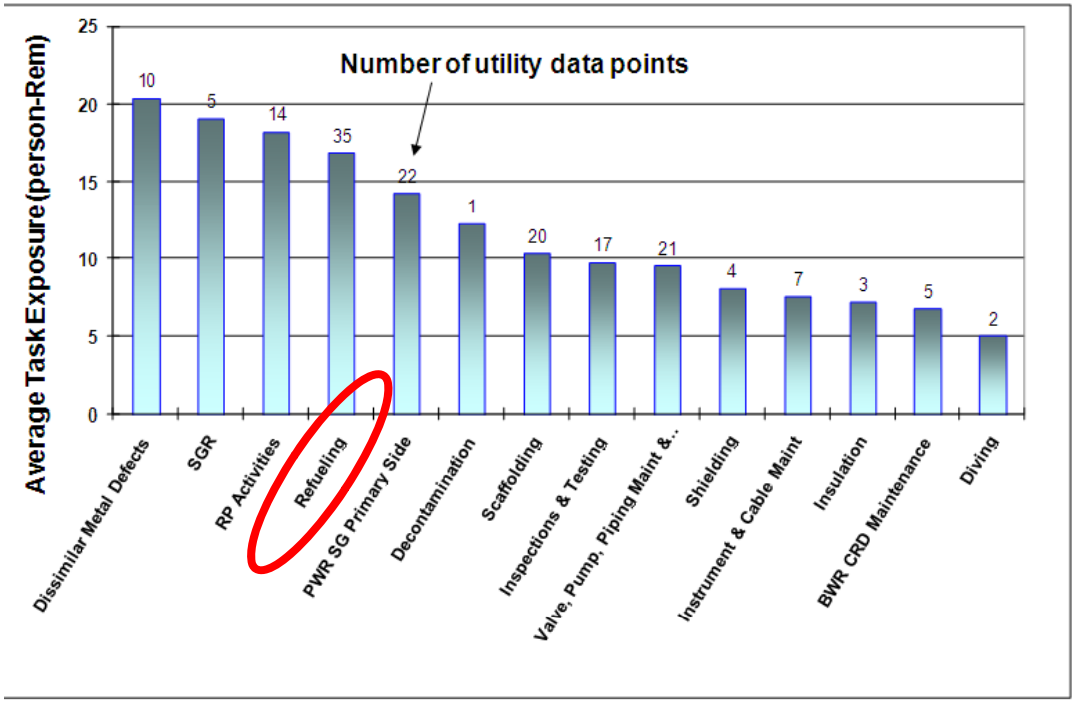
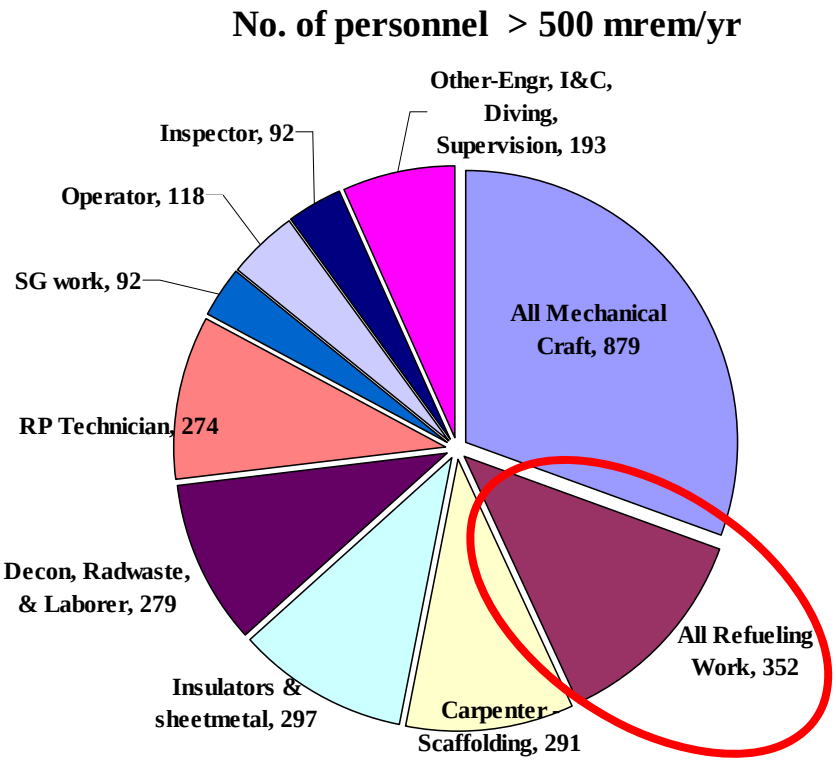
Driver: Evaluation of High Dose Jobs and High Dose Workers in Preparation for 2 Rem Limit (1021100)

Average Task Exposure for High Collective Dose Tasks



Number of Individuals Exceeding 500 mrem/yr by Trade



Refueling is a major repetitive task that merits more focused industry dose reduction efforts.

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Project Approach (2011-2012)

1. Identify task-specific radiation fields and sources (2011)

✓ Capture and analyze detailed site refueling task data from Case Study Sites (Comanche Peak, Dresden)

- Specific activities (time-motion), radiation fields, radiation sources and reactor-specific challenges

2. Identify opportunities for improvement and document plant experiences with alternate technology or technique (2012)

✓ Using information from host site and OE from Working Group

✓ Working Group: chemistry, RP, ALARA, outage management, refuel vendor, INPO

Document Alternative Processes and Technologies That May Help Minimize Worker Dose for Refueling Specific Activities

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Refueling Sequence for Light Water Reactors

PWR Sequence

- Mobilize
- Clean up S/D crud burst
- Cavity dry
- Disassemble
- De-torque head, remove studs and head
- Flood-up
- Remove upper internals
- Move fuel
- Inspect/test
- Replace upper internals
- Drain-down
- Set head
- Reassemble
- De-mobe

BWR Sequence

- Mobilization, Reactor water clean-up
- Vessel flood-up, Drywell head removal
- Vent and head insulation removal
- Vessel head removal, Steam dryer removal
- Steam line plug installation
- Steam separator removal
- Fuel movement, Inspections/testing
- CRD, LPRM work
- Vessel internals rein.
- Steam line plug removal, Drain-down
- Vessel head reinstall.
- Vent and head insula. reinstall.
- Drywell head reinstall., De-mobilization

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Sample Data from Comanche Peak: PWR Case Study Plant

Core Refuel Dose	2RF06	2RF07	2RF08	2RF09	2RF10	2RF11	2RF12
Blind Flange Removal		0.020	0.034	0.048	0.110	0.089	0.031
Rx Vessel Disassembly	4.600	4.020	4.155	3.135	3.362	3.498	2.571
CETNA Disassembly	0.795	0.455	0.485	0.421	0.456	0.566	0.255
Rx Head Lift	0.509	0.088	0.283	0.235	0.331	0.149	0.133
Remove	0.273	0.140	0.044	0.090	0.027	0.076	0.065
Offload Fuel	0.612	0.479	0.423	0.430	0.492	0.360	0.353
Fuel Reload	0.612	0.478	0.344	0.295	0.444	0.333	0.343
Install	0.067	0.107	0.028	0.070	0.140	0.077	0.060
Rx Head Set	2.019	1.104	0.975	0.989	1.246	1.661	3.143
Rx Vessel Reassembly	5.367	4.601	2.854	2.768	4.213	4.632	4.448
CETNA Reassebly	1.674	0.781	0.631	0.299	0.556	0.674	0.397
Rx Head O-Ring Replacement		0.169	0.488	0.284	0.448	0.060	0.157
Blind Flange Replacement	0.248	0.261	0.182	0.096	0.152	0.120	0.111
Incore Guide Thimble Tube Removal							
TOTAL Westinghouse	16.776	12.703	10.926	9.160	11.977	12.295	12.067
RP & Decon Support for Rx Cavity Work	1.700	0.447	1.160	0.463	0.643	0.783	1.365
Cavity Decon	0.711	0.736	0.735	1.531	1.372	0.889	1.669
Total RP Decon	2.411	1.183	1.895	1.994	2.015	1.672	3.034
Core Refuel Dose	19.095	14.065	14.532	11.622	14.069	15.011	15.832

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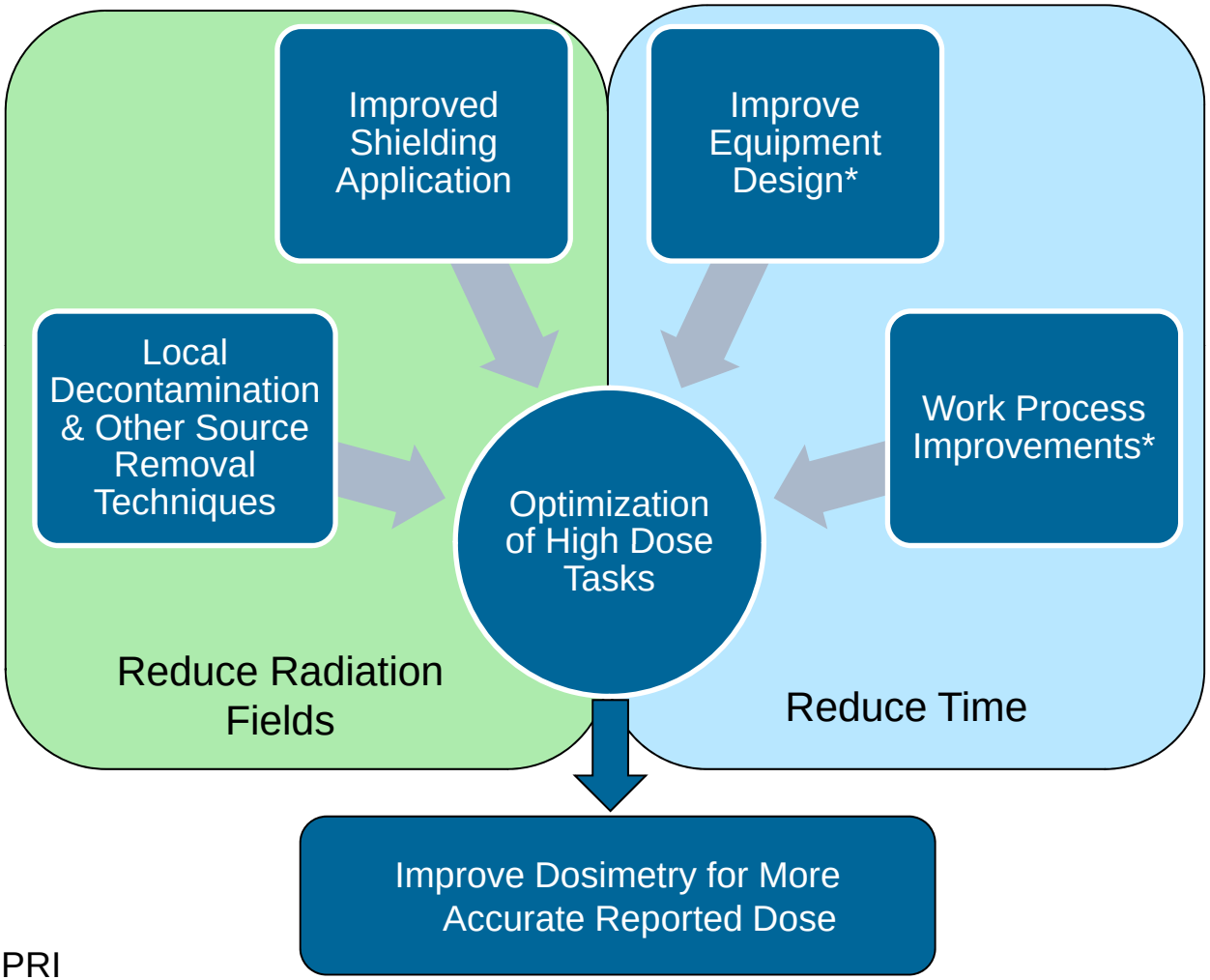
Strategy for Dose Management: Multiple Tools for Optimizing High Dose Tasks



*Leverage EPRI Programs (e.g. NMAC, MRP, NDE)

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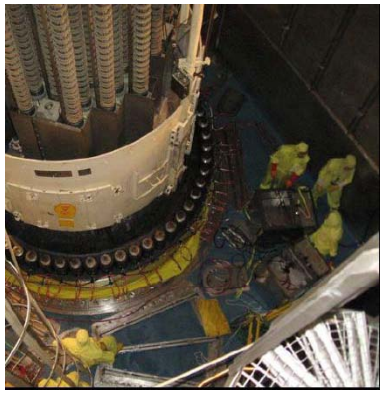
Task Reduction Technologies

- Examples:
  - Rapid fastening systems (e.g. The Hydranut System)
  - Improved job planning (e.g. 3D ALARA planning tools)
- Experience with The Hydranut System
  - Retrofit for existing tensioning system
  - 100% tensioning of all studs simultaneously or individually
  - VC Summer, Dresden, Comanche Peak, SONGS, Younggwang, others



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Experience with Rapid Fastening Systems

VC Summer HydraNuts Closure Duration

Activity	Duration (Minutes)
Install HydraNuts onto RV Studs	45
Install Hydraulic Hoses to all HydraNuts	20
Pressurize system to 3,000 - 5,000 psi	4
Rotate Lock rings into place	7
Release pressure and repressurize to final set pressure	4
Rotate Lock rings into place and release pressure	3
Repressurize to final pressure, check lock rings and release pressure	6
Stud stretch verification on 4 studs	8
Stud stretch verification on 54 studs	60
Total Duration	157

- Examples of benefits:
  - 7 hr reduction in outage time (~$292,000 calc. cost savings, 2.6 person-Rem)
  - Reduced critical path costs by >$600K and reduced personnel from 9 to 5

Lessons Learned:

- Contingency plans for any type of equipment failure
- Mock-up training
- Ensure trained workers are on the schedule for when the work is to occur
- Relocate hydraulic control unit to low dose area on the refuel deck
- Train and inform mechanics of process changes

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Source Reduction Technologies

- Examples:
  1. Head Penetration Flushing
  2. Submersible Demineralizer
  3. Cavity Water Activity Filtration

Seabrook's Tri Nuclear Demineralizer System

Control Rod Guide Tube (CRGT) Flush Tool at Dresden

Fermi Drain Pit Filter

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Head Penetration Flushing

- Top and bottom head penetrations are dead legs, prone to activity accumulation
  - increased dose rate
  - increases friction, affecting component operation
- Dresden and GE-Hitachi developed a flushing tool to <u>decrease friction</u>

Control Rod Guide Tube (CRGT) Flush Tool- 95% Inserted

- <u>Dresden Experience:</u>
  - Applied during 2 outages, flushing 25 of 32 drive tubes
    - 1st outage: 34-75 min. each
    - 2nd outage: ~30 min. each
  - Results:
    - Improved CRD operability
    - 24% reduction in dose rates, ~47.5 Ci removed

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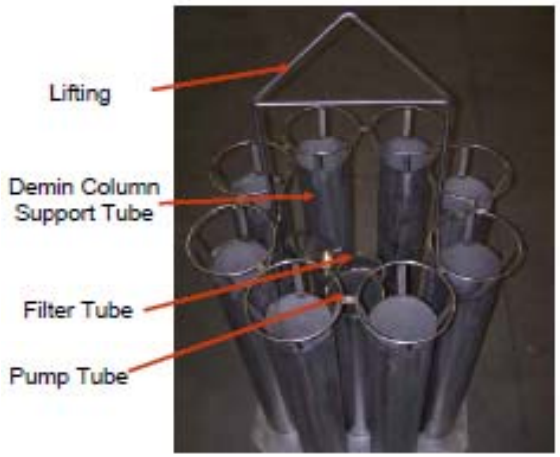
Submersible Demineralizer

Tri Nuclear Submersible Demineralizer (typical)

- Used by several BWRs and in two known PWR cavities
- Includes experiences and lessons learned from:
  - Nine Mile Point
  - Seabrook
  - Palisades



Seabrook's Tri Nuclear Demineralizer System

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Shielding Technologies

- Examples:
  - MHI Tungsten Charging Shielding
  - Integrated head shields
  - Refuel bridge crane shielding

Training Mockup Loop Used for Demonstration

- Used in Japan for pressurizer heater work
- Lead-free shielding system
- Use water to remotely charge application-specific forms (jackets) with tungsten balls
- Jackets are designed for specific locations or generic configurations
- EPRI demonstration conducted at Calvert Cliffs

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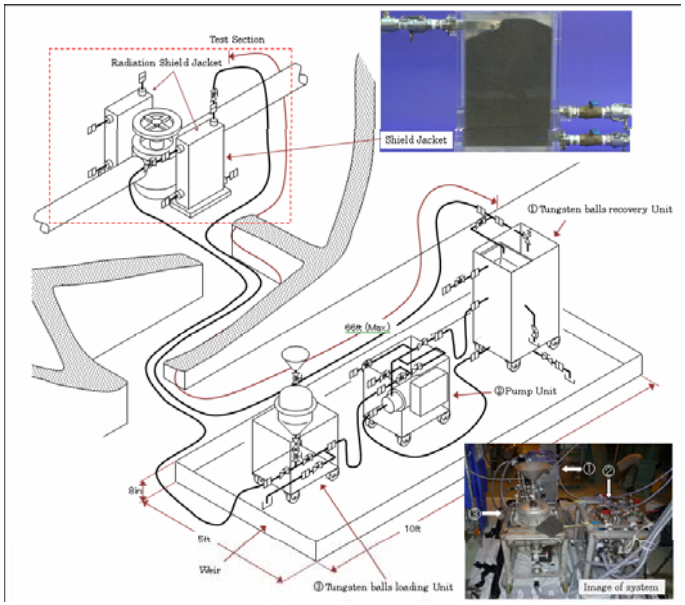
Demonstration of MHI Tungsten Charging Shielding System at Calvert Cliffs



General Arrangement for Charging System

Relative Size of the Tungsten Shot

- Positives
  - Single charging system for multiple jacket applications
  - Addresses GSI-191 issues
  - Reduces/eliminates handling of heavy shielding materials (e.g. lead blankets)
- Opportunities and Lessons Learned
  - ❑ Improve shot containment (FME)
  - ❑ Erect berm/barrier for all equipment
  - ❑ Connect hose to jackets prior to installation (for some applications)

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Other Topics Included in Report

- Detailed refueling data analysis for each case study plant
- Analyses for high dose priority tasks
- Evaluations of other technologies
  - Review of robotics and semi-remote processes
  - Brief review of cavity decontamination options
- Need for standardization of refueling dose tracking categories

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Summary

- Some plants have been successful at seeking new technologies and techniques but implementation is not uniform across the industry
- Additional opportunities/needs were identified:
  - Alternate alignment and guide technology for reactor head set
  - Optimization of cavity decontamination techniques and application process
  - Further refinement of the CRGT process for BWRs and a design for PWRs

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