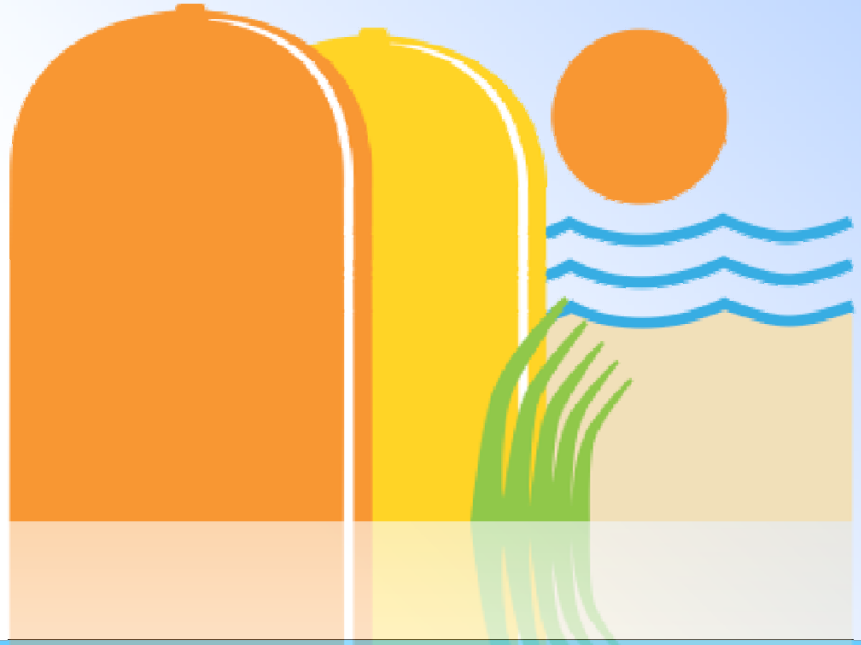


Cook 1&2 US Lowest 4 Loop PWR Refueling Outage Dose: ALARA Achievements & Lessons Learned

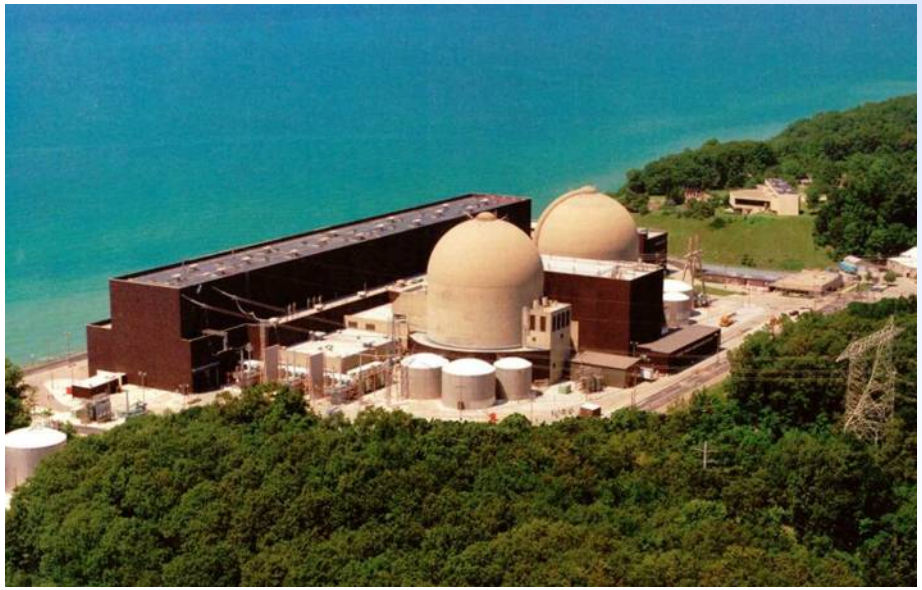
David W. Miller, PhD

Cook Nuclear Plant

2010 ISOE International ALARA Symposium

Cambridge, UK

Cook Improvements in Outage Dose, CRE Performance & Five Year ALARA Plan to Meet INPO 2015 PWR Goal



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Objectives of Presentation

1. To show the importance of developing an ALARA plan to meet the INPO 2015 dose goals & fully implementing the plan

2. To share with industry one source term reduction strategy that effectively reduced occupational dose

3. To maintain focus on the fundamentals of good RP management in the midst of major plant component failures and repairs

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Cook Five Year ALARA Plan

- **At Cook, the 5-Year Dose Reduction Plan is the road map to superior ALARA performance.**
- **The Plan is periodically updated to reflect the status of dose reduction initiatives and changes to programs and processes.**
- **The ALARA Committee reviews and approves the initiatives contained in the Plan annually in the formulation of the ALARA Top Ten list.**
- **Approval of the Plan signifies management commitment to the initiatives contained within**

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Cook Unit 1 & 2 ALARA Challenges

- Development and execution of 5 year plan
  - Clear benefit, not just dose but eliminating risk
  - Clear owners with due dates
  - Clear cost to allow appropriate forecasting
- Resource commitment
  - Spent ~$25,000,000 on just alara dose reduction initiatives
- Dedication
- Manage distractions

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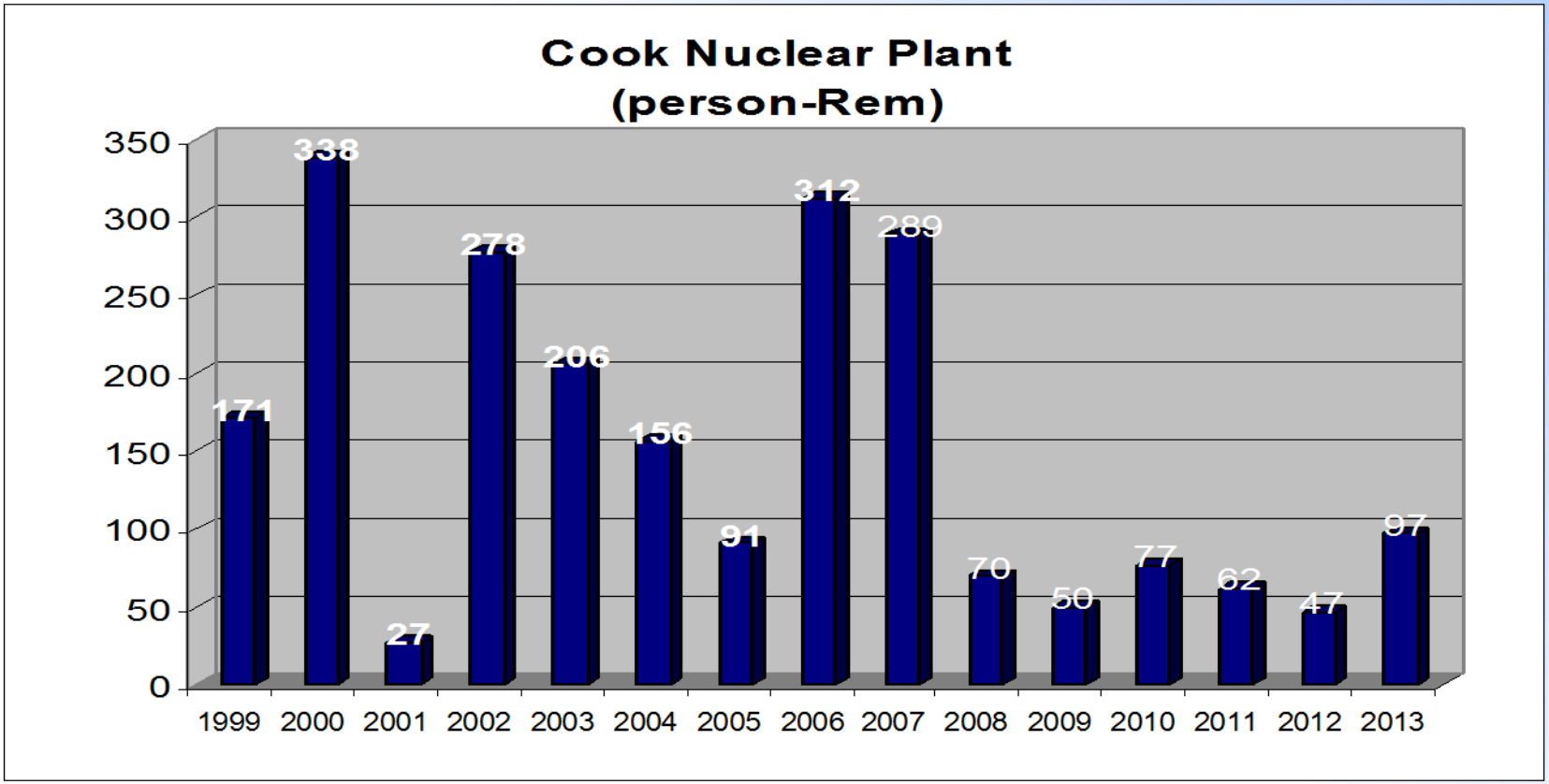
Cook Units 1 & 2 Dose Projection 2013



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U2C23 - Outage dose projections of 270 person-mSv

- **Fall, 2010 scheduled outage**
- **Goal to beat Point Beach (2 loop PWR) US PWR outage dose record of 282 person mSv.**

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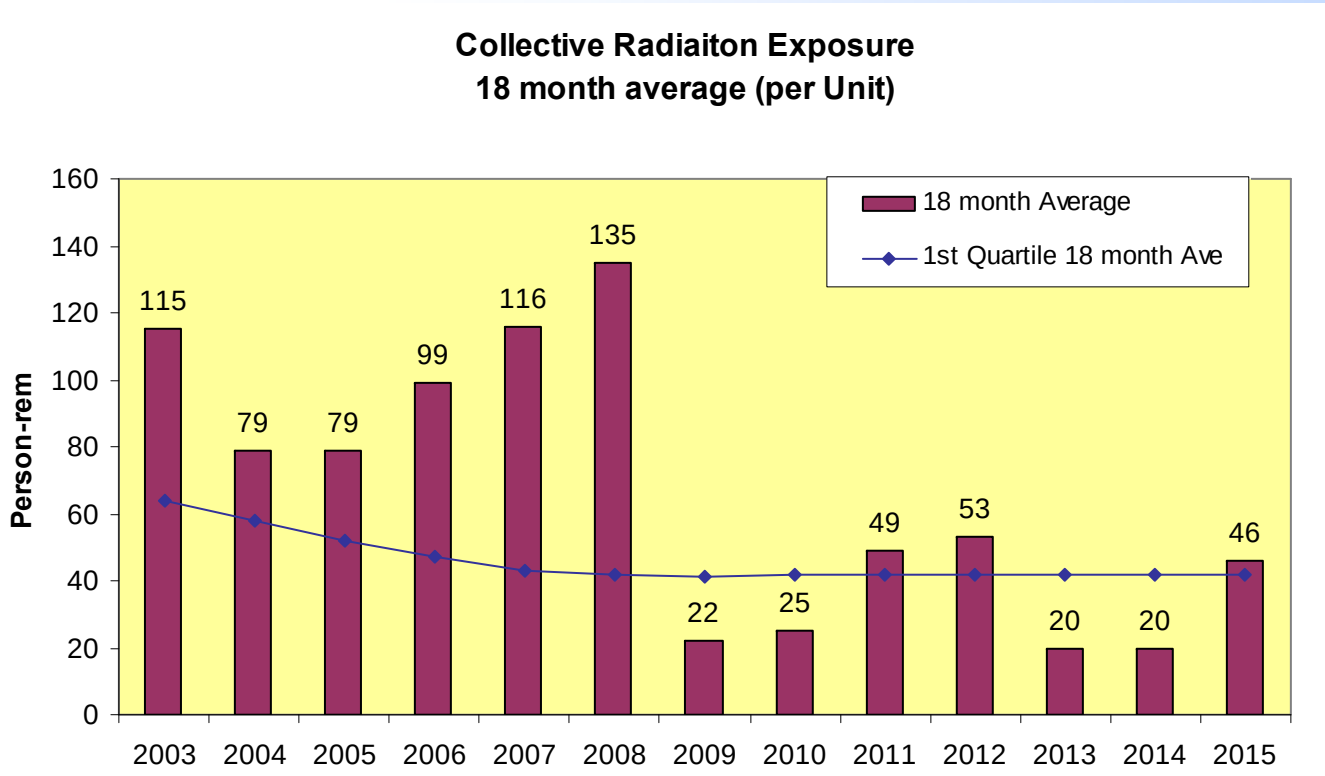
18 Month Rolling Average for Cook 1,2



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Cook Refueling Outage Dose Projections

- 2010 Dose (77 person-Rem)
- Non-outage dose - 7 person-Rem
- U1C23 - 36 person-Rem, Spring,
- U2C19 – 27 est. person-Rem, Fall, 2010

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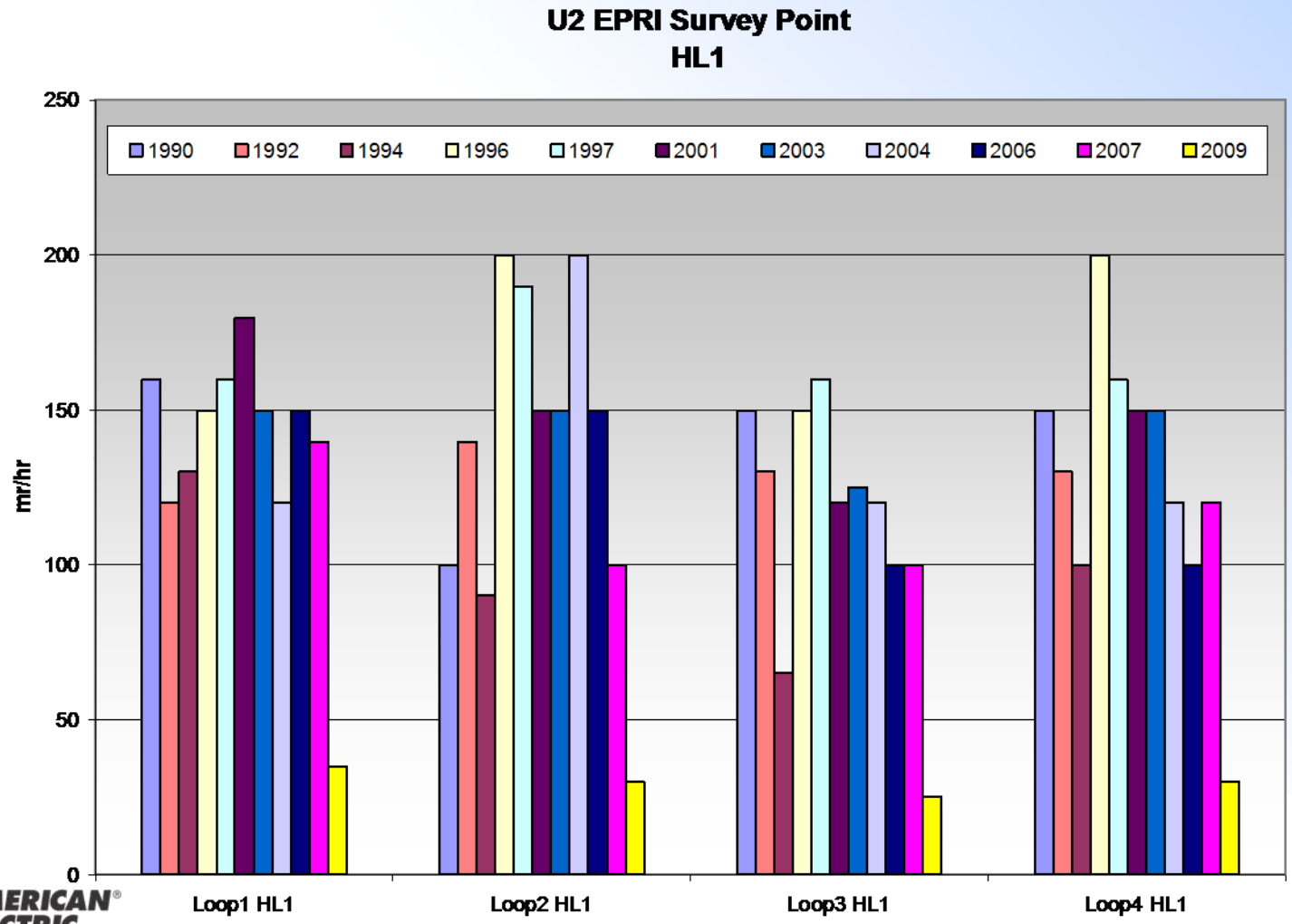
Westinghouse/EPRI Base Line Measurements Decline in Dose Rate



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Spring 2010 Unit 1 Outage Dose Results

- **35 person rem outage**
- **38 days**
- **30 Personnel Contamination Events**
- **10.5 person rem for mechanical stress relief of pipes.**
- **4.0 person rem for scaffolding**
- **5.0 person rem for 10 year ISI on Core Barrel**

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Unit 2 Cycle 23 Refueling Outage Results

- **Crud Burst peak was low enough to allow immediate entry to upper and lower containment**
- **Saved 6-12 hours of critical path time**
- **Seventh use of the specialty resin**
- **Use of PRC resin on startup to remove Nickel (when 90% is being released from Steam Generators) lowers Co-58 production.**

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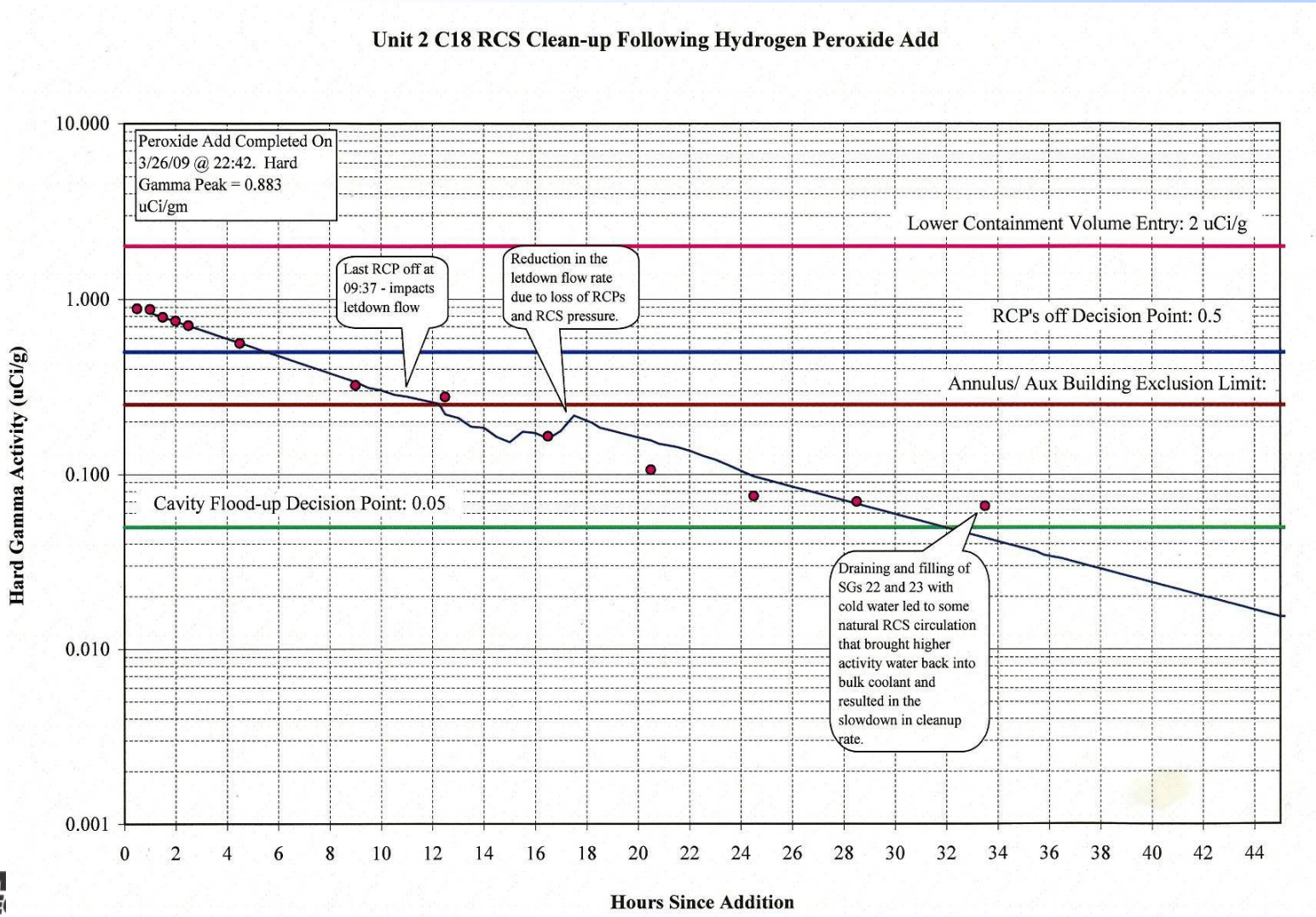
RP Decision Containment Access Chart



Unit 2 Outage Source Term Results

- **Key chemistry data from U2C18 outage:**
- **Total Co-58 & 60 removed: 767.8 Ci**
- **CRUD burst peak: 0.855 µCi/g**
- **CRUD Burst Estimate: 0.87 µCi/g**
- **Total Ni removed: 1003 grams**
- **Clean up time: 39.5 hours**

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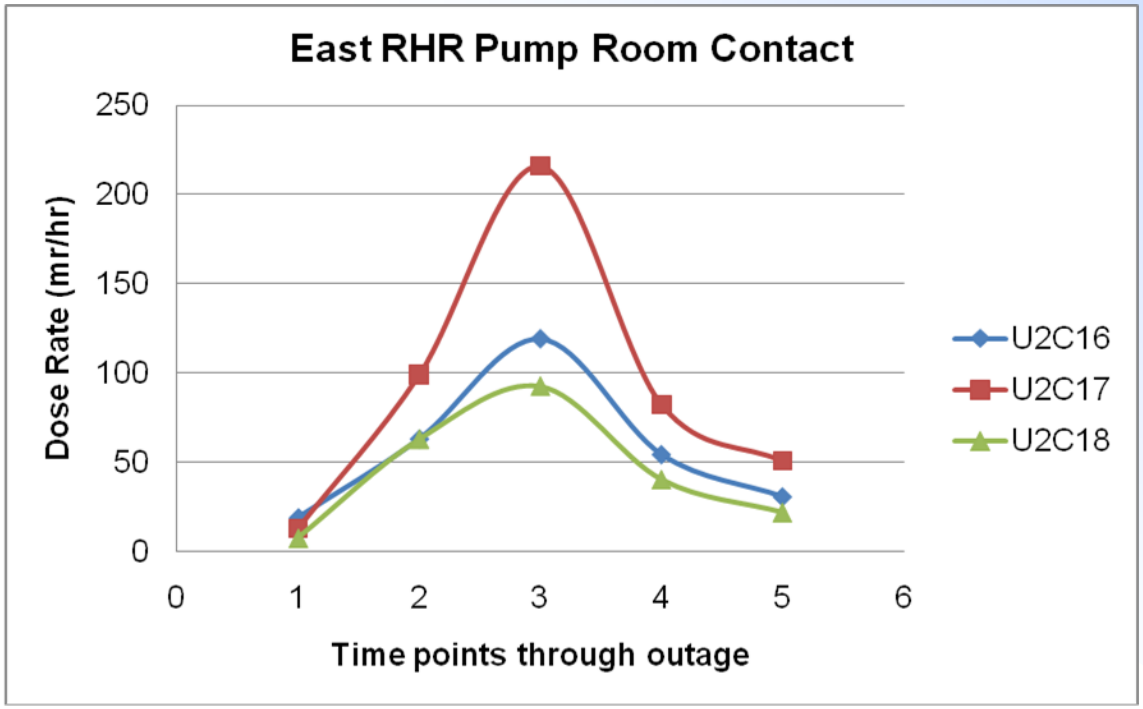
Teledosimetry for Past 3 outages Crud Burst



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Benchmarking site visits to Cook from other US PWRs after 2010 NATC ISOE ALARA Symposium in January 2010

- **First Energy Corp visited Cook & NATC in April 2010: Beaver Valley and Davis Besse continued to use PRC resin**
- **Duke Energy Benchmarking in May 2010 for McGuire, Oconee (sister plants to Cook) and Catawba –decision follow Braidwood**
- **Exelon Nuclear Benchmarking in May 2010 – decision to implement PRC at Braidwood 1,2 for next 4 cycles, then compare with Byron 1,2**

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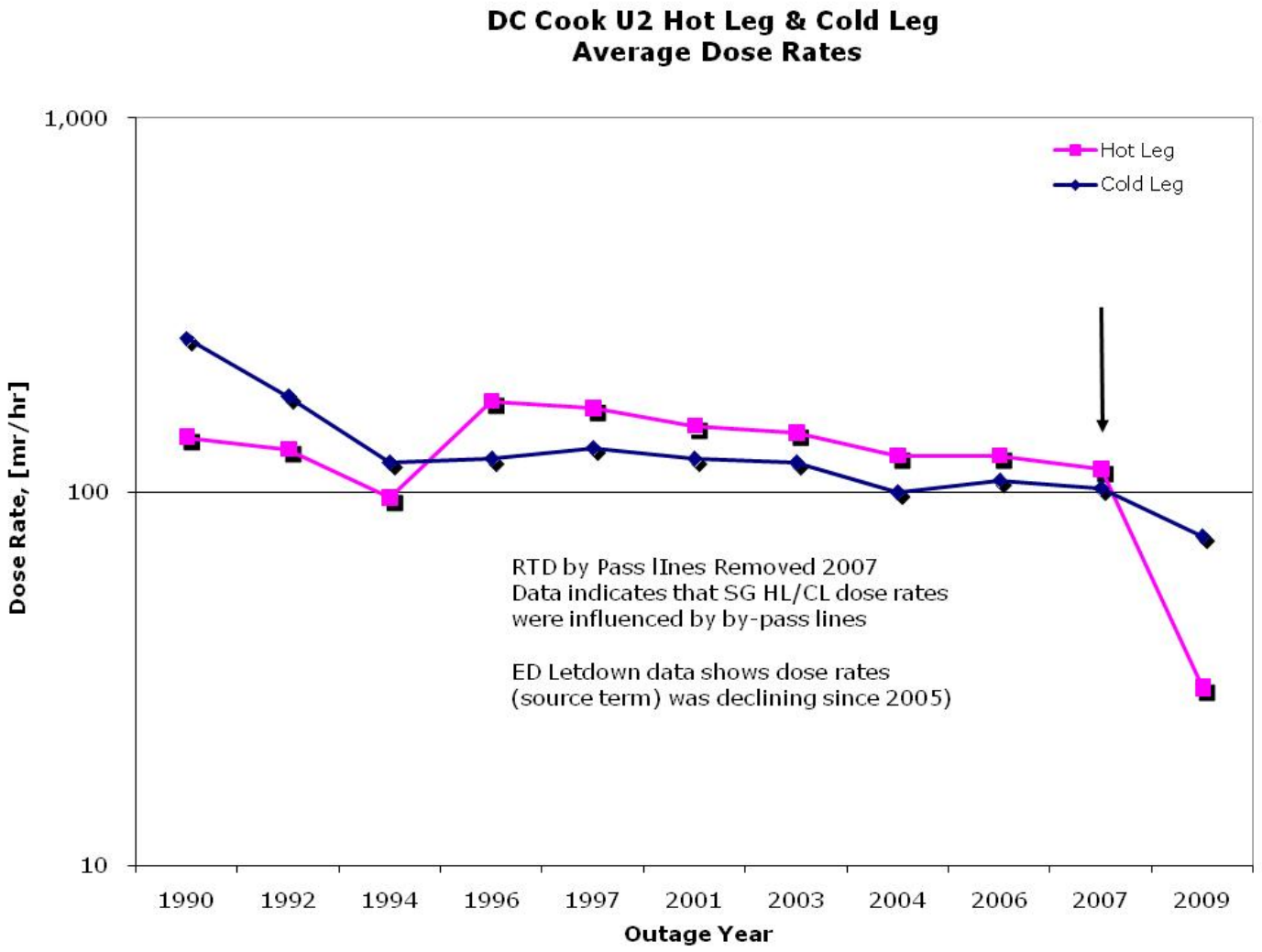
RTC Bypass Line Removal Results



Cook Dose Results

- **Decreased annual dose from worst to best US PWR units in 5 years.**
- **12 PCEs for fall outage**
- **Unit 2 outage dose of 28 person rem**
- **No positive airborne for 3 years**
- **Deletion of 5 temporary shielding packages due to low dose rates**
- **High cavity water clarity**

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U1C23 – 36.335 p-Rem Spring 2010 Final Dose

Outage work scope included:

- Outage dose reductions realized by:**BMI Under vessel inspections, Risk informed ISI inspections, Refueling activities.New Reactor Head – less inspections**

- **10 Year ISI Reactor Vessel Inspection**
- **Continued use of PRC-01 resin**
- **Mechanical Stress Improvement Process (MSIP)**
- **Increased use of remote monitoring**
- **High capacity factor achieved for both units with minimum forced or maintenance outages for source term control. If the unit experiences a forced outage to Mode 5, followed by a CRUD burst PRC-01 resin use to mitigate colloids.**

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How Resin Works to Remove Co-60

- **Fundamentals of Flow Dynamics**
  - **Hydraulic boundary layer is ~ 200 um thick at 28 m^3/hr**
  - **Colloids 2,000 X smaller than boundary layer**
  - **Colloids have little mass and cannot penetrate through the hydraulic boundary layer to macro-pores**
  - **Colloid flow is around beads with fluid streamlines**
- **Macroporous Resins**
  - **Are not effective for colloids since no Pore flow is possible**
  - **And larger particles (>1 um) plug pores**
- **PRC Surface Nano-Hairs provides high interception probability for colloids**

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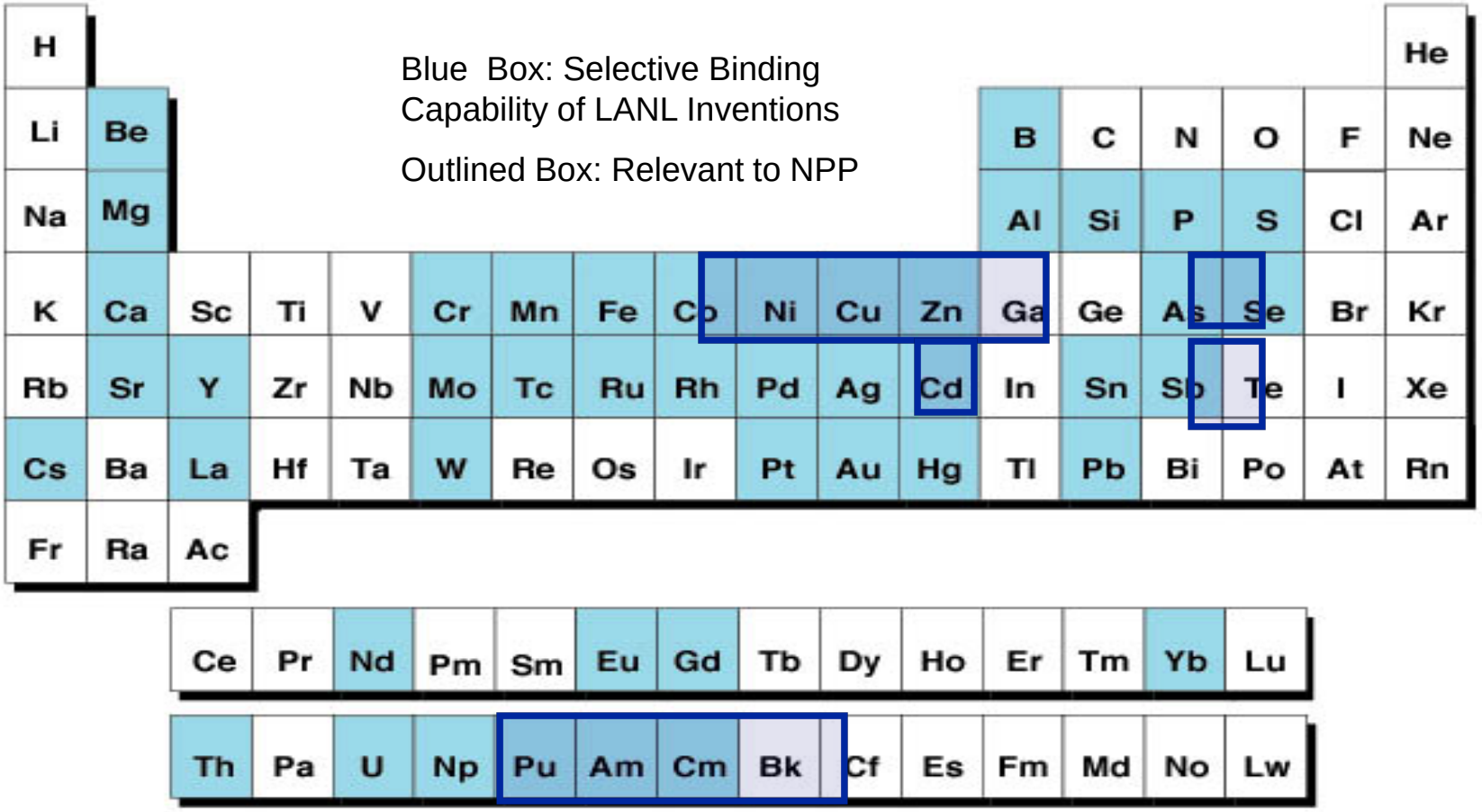
R&D 100 AWARD Winner for Polymer Filtration Technology

- **Customized for target contaminate**



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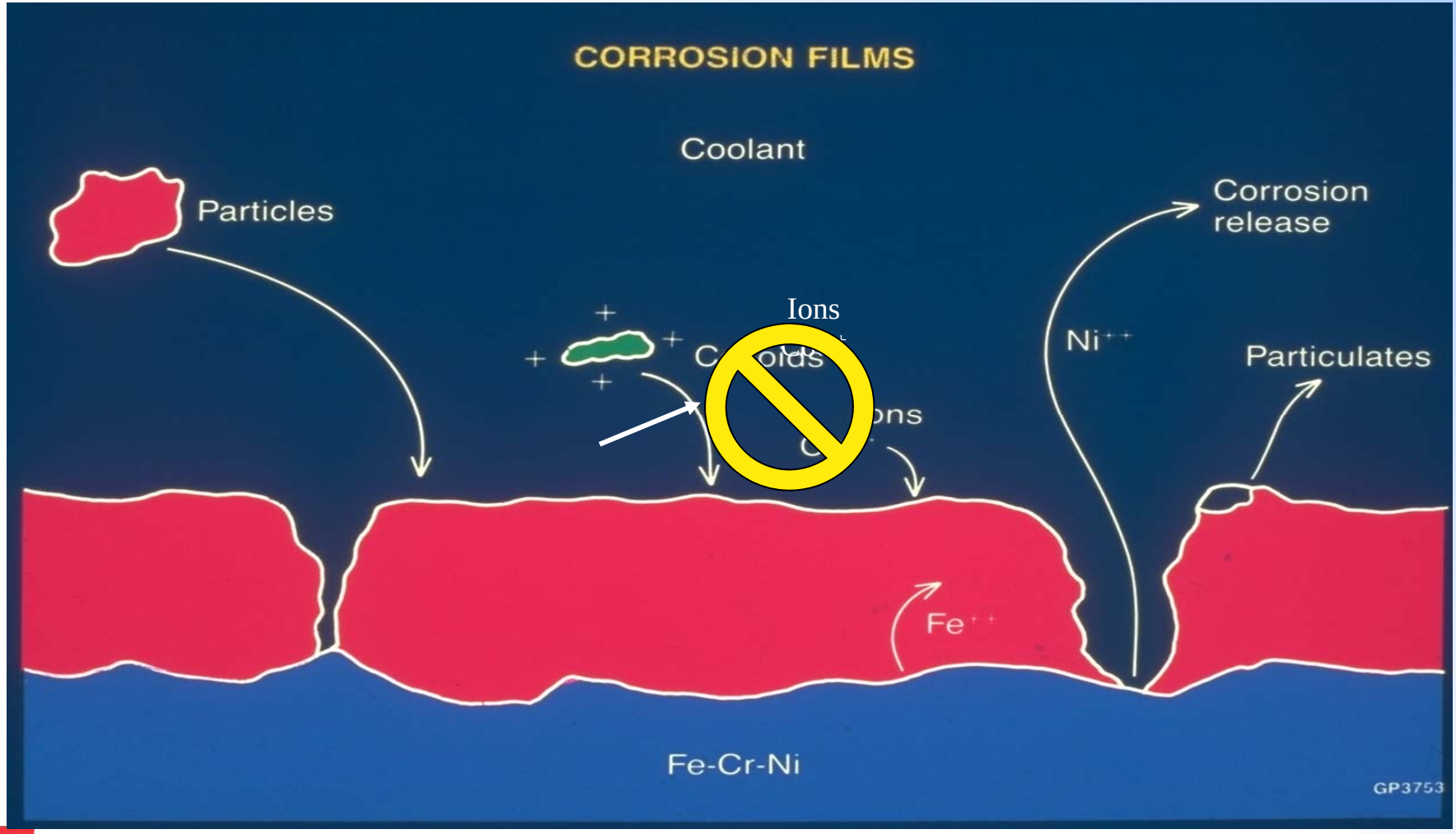
Simple Corrosion Film Deposition Model

What We Knew… and Had Not Solved…



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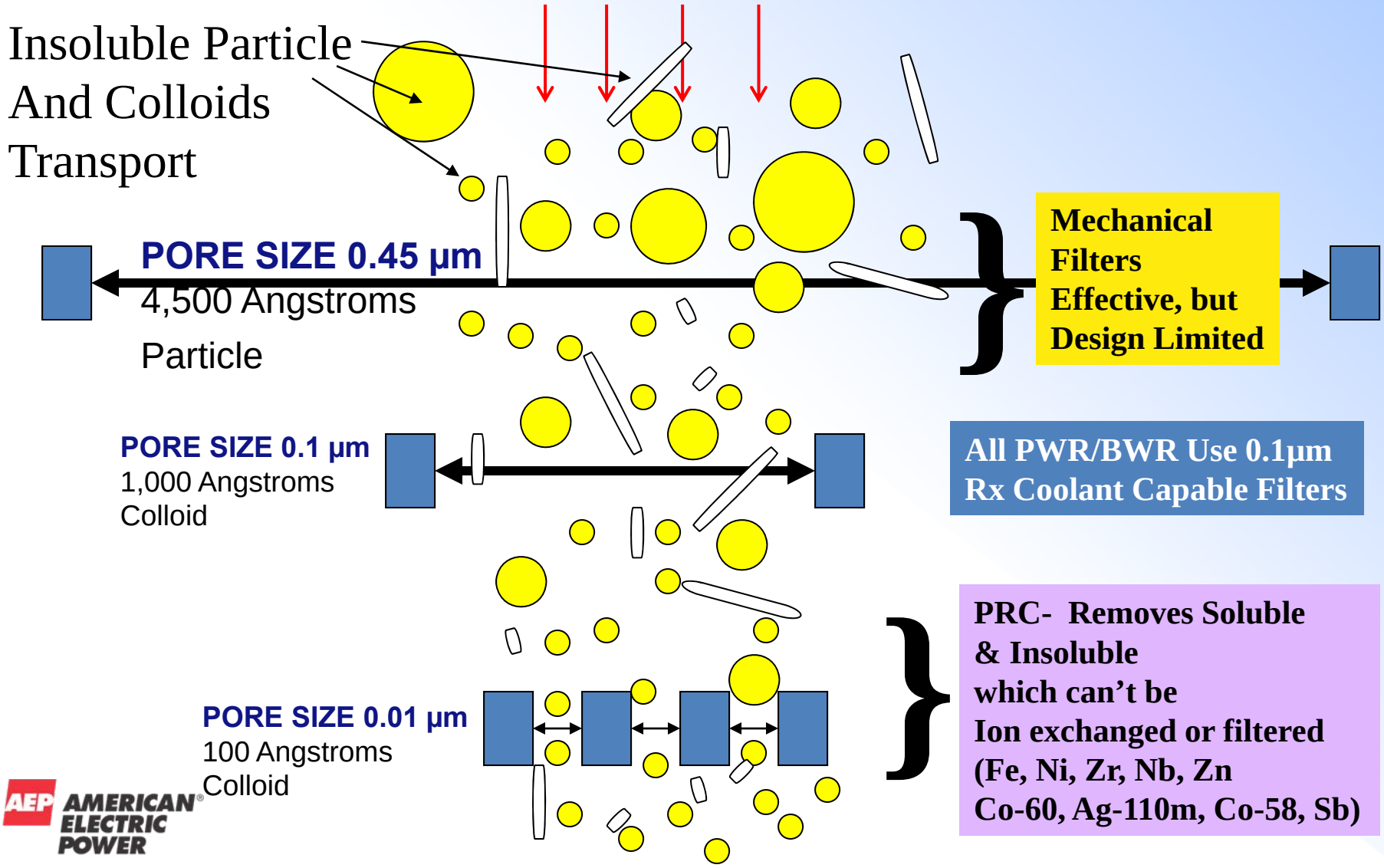
Colloids Are Extremely Small (<.1 um) Insoluble Species; cannot be filtered by mechanical RCS Filters



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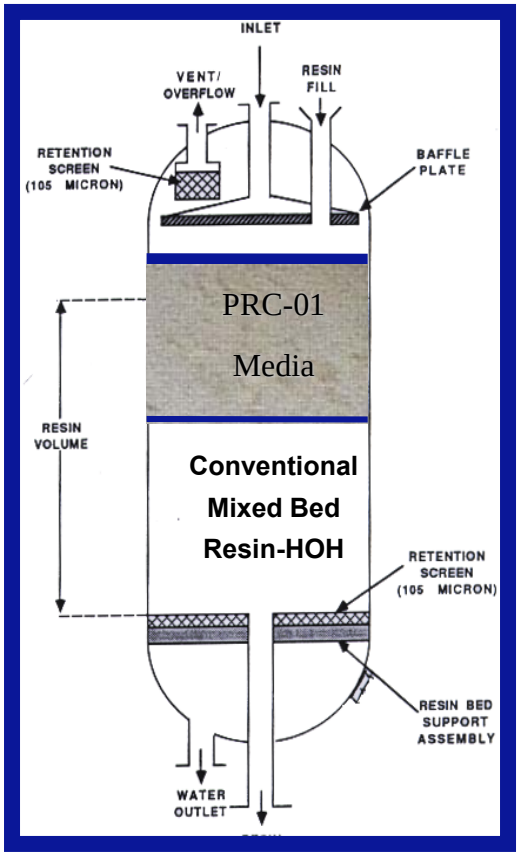
PRC Resin Uses Existing Demin. Vessel



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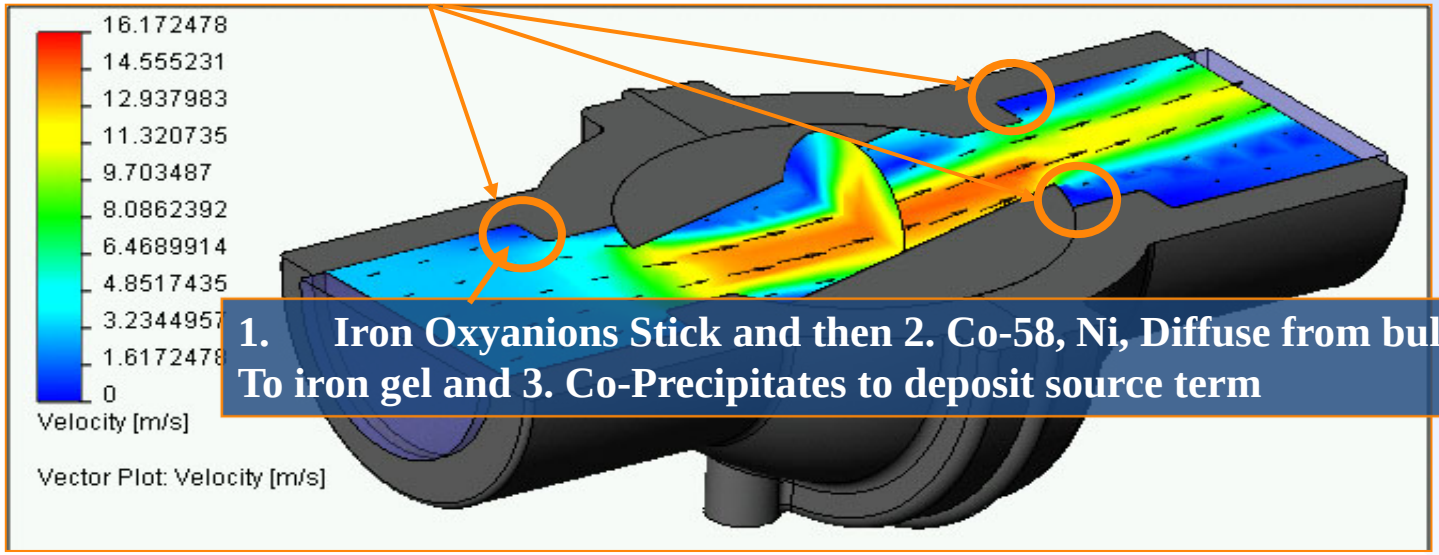
Problem is IRON Chemistry NOT Co-58/60 Chemistry Mechanism of Deposited Activity

- **Iron Oxyanions Form in RCS during Shutdown**
- **Iron Gels Stick/Deposits in CRUD Traps& Pipe**
- **Co-58, Co-60, Nickel diffuses from bulk RCS to boundary layer of gels where it "Sticks" or co-precipitates into Iron Gels**
- **Result increased dose rates, contamination and degraded Source Term**
- **Impossible to complete a mass balance: Released - Deposited - Removed CVCS = 0**



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Keeping Focus of Execution

- **On Saturday, September 20, 2008 at 2005 hours, the control room experienced simultaneous high-high vibration readings on all main turbine bearings with severe vibration and rumbling felt coming from outside the control room.**
- **The reactor operator manually tripped the reactor within 5 seconds, all control rods fully inserted, and major systems functioned as designed (Good operator response).**
- **Turbine generator went from 1800 RPM to 0 RPM in less than 2 minutes.**

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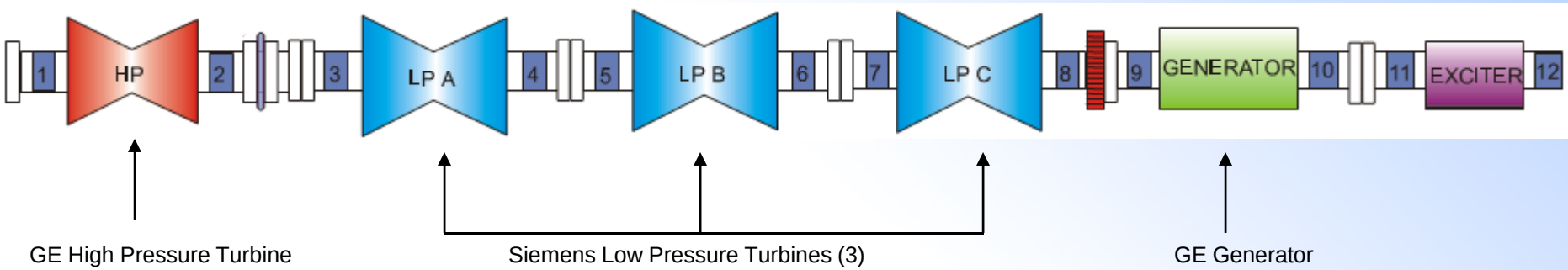
Event Description

Unit 1 Main Turbine-Generator Overview



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Summary

- Fire damage to main generator/exciter housing
- Turbine damage
- Piping insulation damage
- Visible concrete damage around turbine
- Oil spills
- Damaged hangers and supports on various pipe systems

Excellent Response to Event- No Injuries

Executive Summary

- LP turbine exhaust hoods
  - LP turbine exhaust hoods display evidence of blade impact
  - All blades were contained within turbine hoods
  - Bearing housings were displaced

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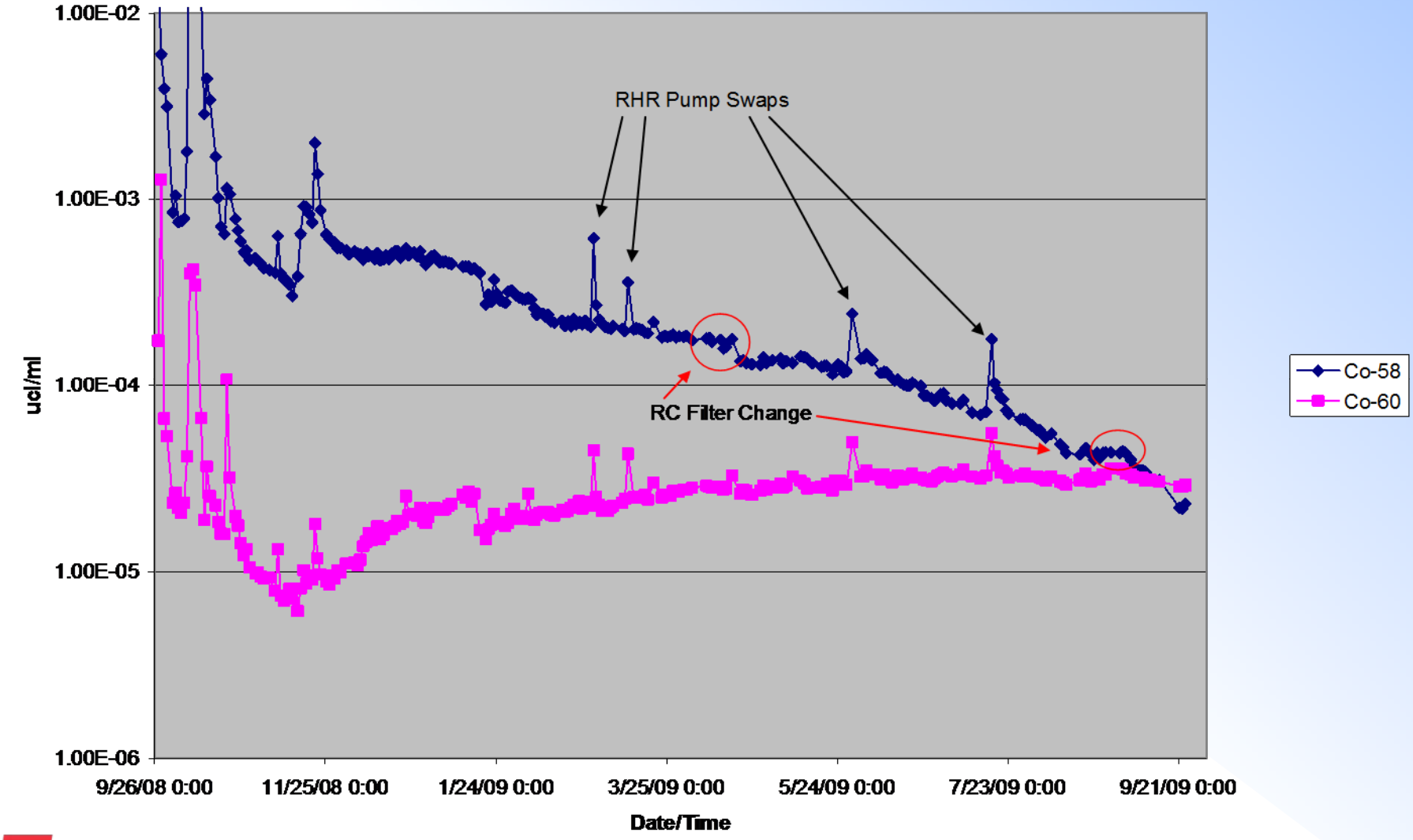
Magnitude of Event

- 59,500 pounds (210 miles) of weld rod
- 43,000,000 pounds safely lifted
- 18,720 rotating blades replaced
- 17,140 stationary blades replaced
- 80,000 pounds of material removed from LP rotors
- 14,800 tasks were completed
- 27,700 ft^3 of asbestos removed (71 basketball courts 1” thick)
- 12,561 air samples taken
- 8,000 ft2 of lead paint removed

Magnitude of Event

- 48,571 (~108/day) work observations performed
- 486 cables replaced and 58,000 feet of temp cable used
- >3,000,000 person-hrs worked No lost time or restricted
- 5,500 Linear feet of pipe was removed and replaced
- 85,000 parts tracked
- Erected enough scaffolding to build a road 10’ high by 10’ wide for 4 miles
- 960 engineering requests generated
- 23 motors removed and shipped for repair and installed
- 12 bearings rebuilt/replaced

Unit 1 Co58/60 Since Turbine Event



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Cook ALARA Lessons Learned

- **Continued use of PRC-01 resin on shutdown CRUD burst & expanded use on S. Deborator to capture Ni on startup to minimize Co-58 coolant concentrations.**

- **Minimize time at 350-200 degrees F coolant temperature to avoid Fe oxide solubility off the fuel and piping.**

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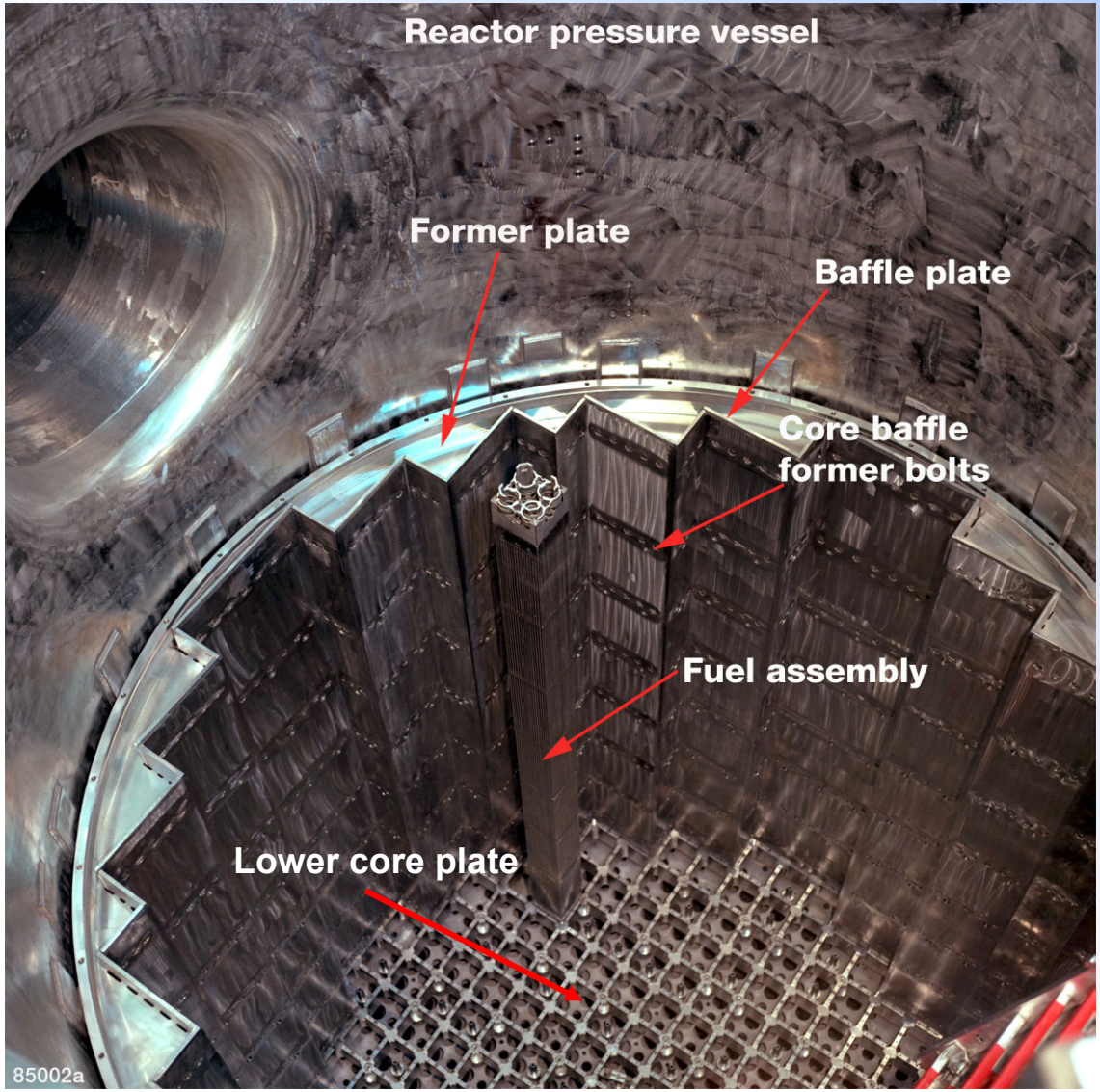
Unit 2 Cycle 19 Refueling began 10/6/10

It is normal practice during a refueling outage to totally unload the reactor fuel from the reactor core. After this is done we do an inspection of the lower core plate.

The former and baffle plates provide structure for the fuel assemblies and direct water flow through the reactor.



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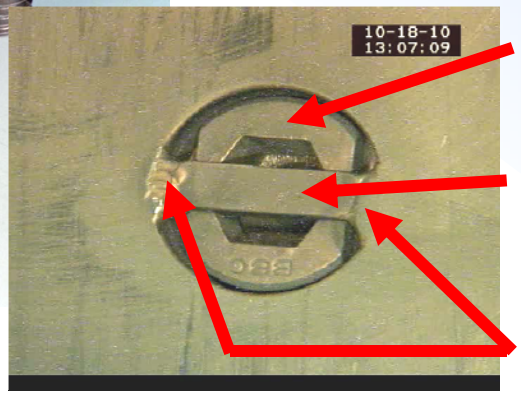
What is a baffle bolt?

Baffle bolts hold the vertical baffle plates to the horizontal former plates.

Cook's baffle bolts are 5/8 inch in diameter and about 2 inches long.

Once bolted in place, a lock bar is welded across the bolt head to secure the bolt.



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Discovery of Baffle Bolt issue at Cook

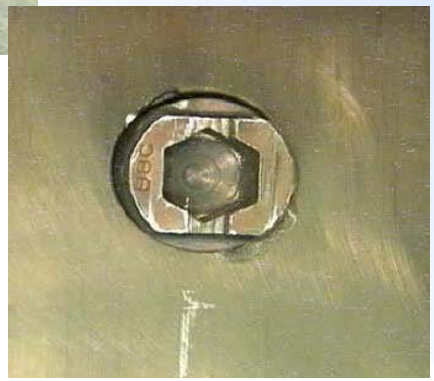
During the lower core plate inspection, we discovered six pieces of foreign materiel: four locking tabs and two cap screws identified as pieces of baffle bolts.

Every baffle bolt location was videotaped.

These pictures show the three types of problems discovered on 18 bolts.

Missing bolt head

Cracked lock bar weld



Missing lock bar

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Current state of actions (as of 10/28/10)

- Completed inspections of the baffle/former bolt locations with a high definition camera
- Began failure mechanism analysis
- Finalizing repair plans and determining extent of condition
- Damaged bolts being removed
- Selected (highly radioactive) bolt parts shipped to Westinghouse for failure analysis
- Repair teams and equipment being mobilized in the U.S. and Germany
- New bolts being manufactured
- Preparations to pull core barrel
- Repairs to be done in the refueling cavity below the water surface for shielding

Reactor core barrel

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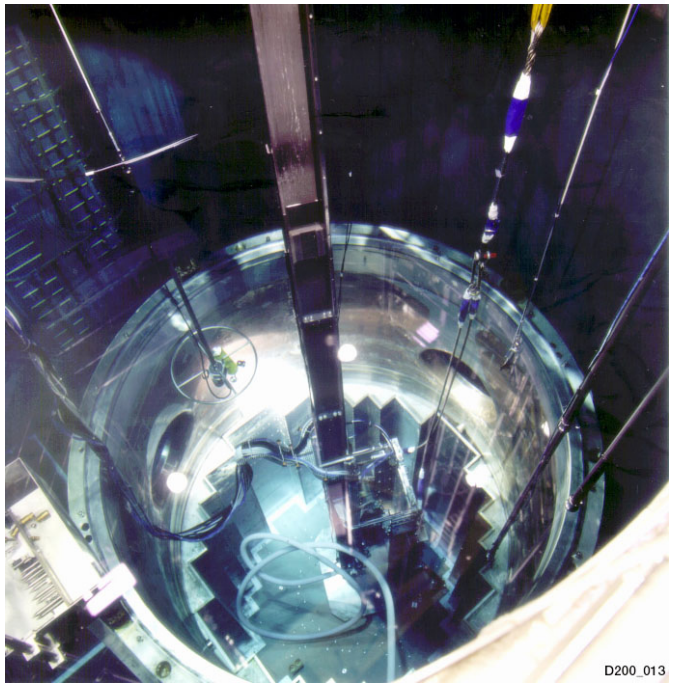
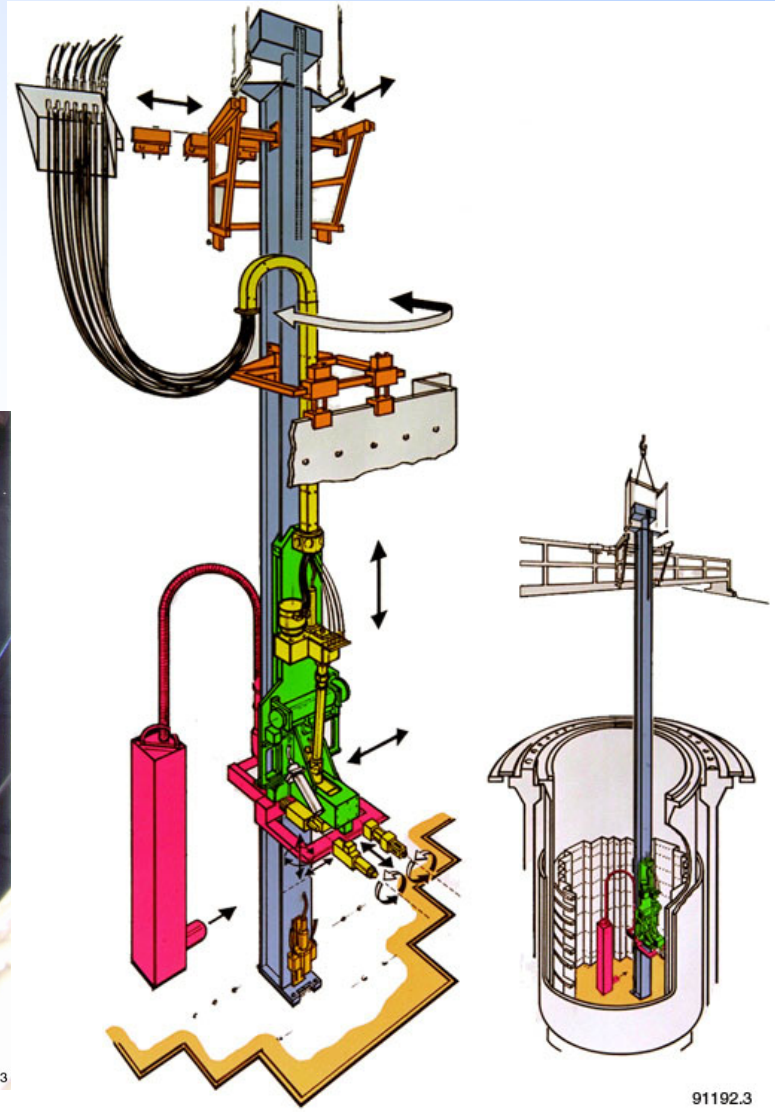
Highly specialized repair equipment

- Repair tooling needs to be refurbished and shipped
- Radioactive shipment of 3 large sea vans requires dedicated air transport from Germany
- Scheduled to arrive Nov. 1 with three day set-up period
- *(right)* diagram of repair tool and picture of tool in place





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Bolt repair scope and process

- Replace all 18 damaged bolts
- Remove, inspect and replace 7 bolts within pattern of degradation
- Remove, inspect and replace 6 bolts on the periphery of the damaged bolts
- If no additional failed bolts are identified, we will conclude that damaged bolts can be identified via inspection and no additional bolts will be removed and replaced
- It is currently believed we will have to expand scope to 8 more bolts

Replacement bolts don't require welded lock bar

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Nuclear safety above all else

We have the right people, a good plan and the experience to successfully complete repairs and return the unit to service.

While the complete scope is yet to be determined, we are using proven repair methodologies.

The delay is disappointing, but all of our decisions are driven by a nuclear safety-first principle.

We also will strictly adhere to industrial and radiological safety work practices during these repairs.

All necessary repairs will be made now rather than have to return and address this issue again in the future.

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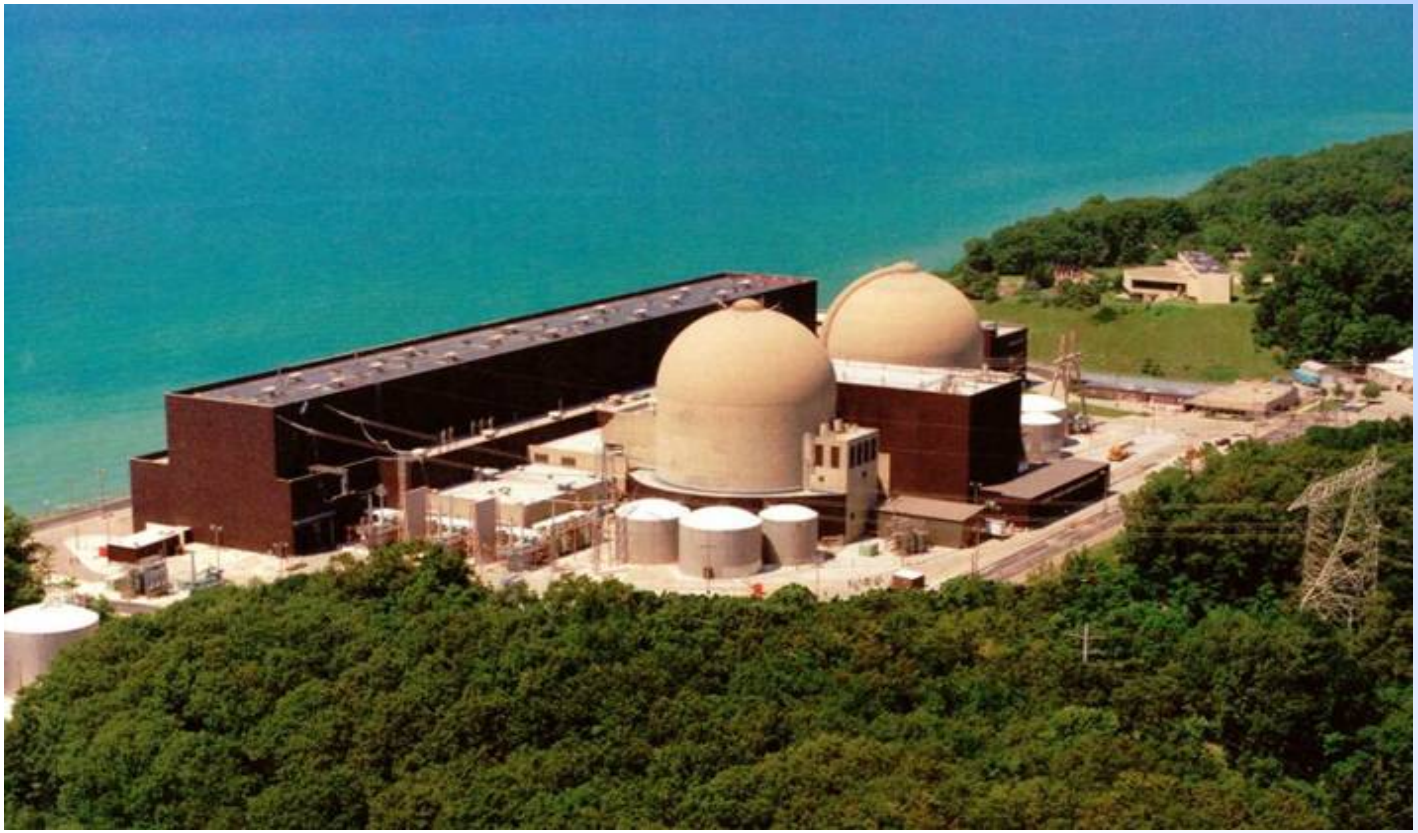
You are Welcome to Visit Cook NP



Thank You Merci

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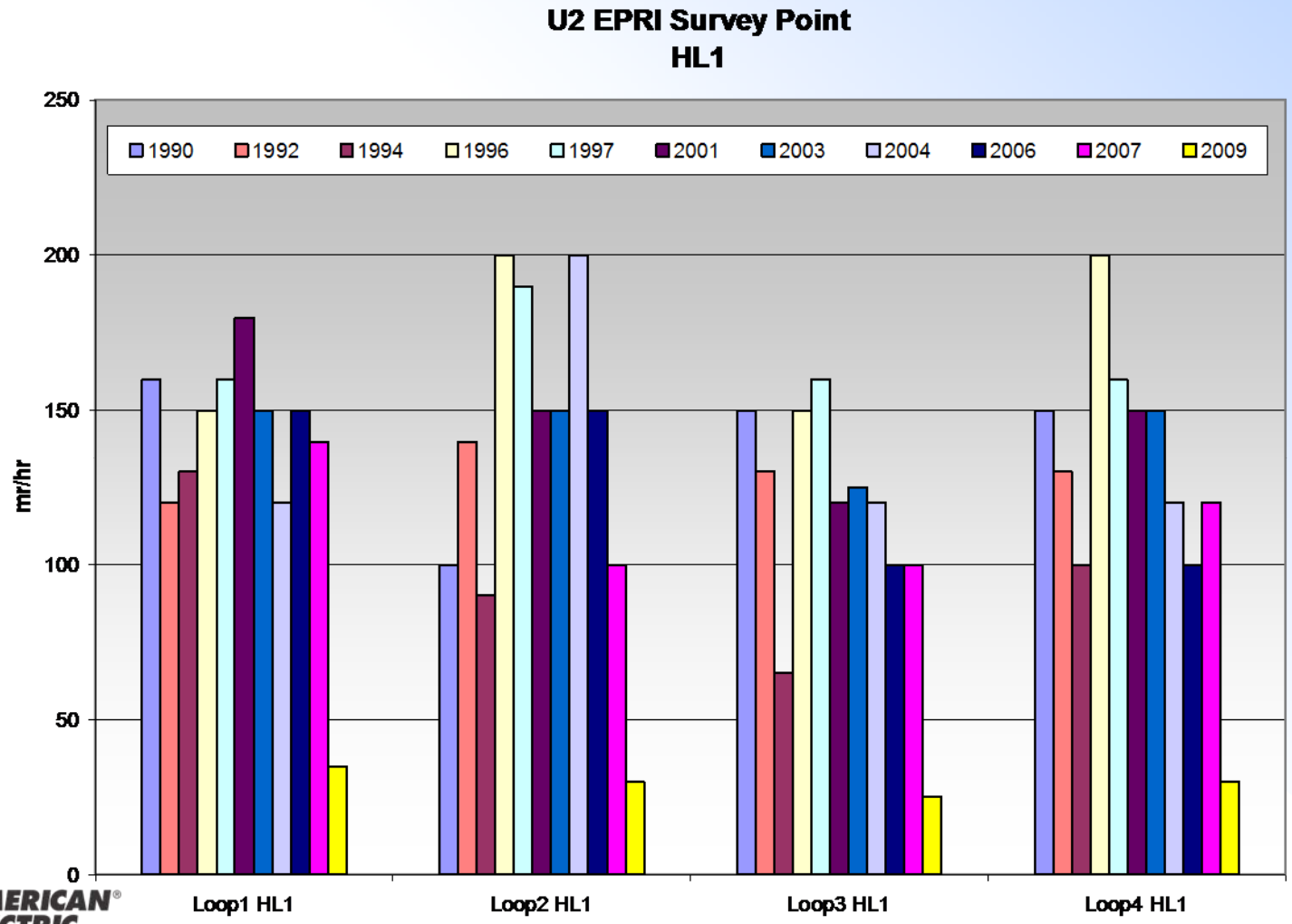
Steam Generator Dose Rate Measurements Decline



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