Achievement of Lowest PWR Dose at Cook Nuclear Plant

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Presentation Outline

- **Success Approach**
  - What the DC Cook DID to Achieve Such Success?
- **Duplicating Success**
  - Benchmark and Mimic What DC Cook Implemented
  - Remove Biases and Obstacles with Data
- **Brief Highlights of Results for DC Cook**
  - Co-58/60 Peaks
  - SG Dose Rates
  - Particle Isotopic Mix

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NRC 2010 PWR Quartile Improvement -44% Three CRE

- **1st Quartile**
- **Improving Every Period**

2010 PWR Quartile Data

	Plant Name	Three-Year Coll. TEDE per Reactor Year 2008-2010	Percent Change From 2007-2009	2007-2009 Quartile (if changed)
1st Quartile	INDIAN POINT 3	25.049	-57% ▼	2
	COOK 1,2	33.291	-44% ▼	2
	FARLEY 1,2	34.000	-8% ▼	
	SUMMER 1	35.757	-1% ▼	
	CALLAWAY 1	36.431	-12% ▼	
	PRAIRIE ISLAND 1,2	39.208	26% ▲	
	PALO VERDE 1,2,3	41.159	-9% ▼	
	HARRIS	44.778	15% ▲	

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DCCook #1 WANO Ranking
Design: 4 Loop > 1000 Mwe, W or F Design

WANO Ranking of CRE By Design:
4 Loop, > 1000 Mwe, Westinghouse Framatone

Rank	UNIT NAME	COUNTRY	MWe RATING	First Commercial Operation DATE	Nominal Operating Cycle Months	3-Yr CRE (Man-Sieverts)	3-Yr CRE [REM]
1	**Cook Unit 2**	**USA**	**1133**	**07/02/82**	18	0.28	27.80
2	Golfech 1	France	1345	01/02/95	18	0.29	29.47
3	Golfech 2	France	1345	03/02/98	18	0.31	31.17
4	Catawba Unit 1	USA	1153	06/30/89	18	0.32	31.60
5	Civaux 2	France	1495	09/02/06	24	0.35	34.66
6	**Cook Unit 1**	**USA**	**1056**	**08/24/79**	18	0.35	35.30
7	Saint-Alban 2	France	1335	03/02/91	18	0.35	35.40
8	Paluel 4	France	1330	06/02/90	18	0.35	35.43

- DC Cook Outages:
  - **RWP- hrs. are 20,000 to 25,000 hours**
- Ice Condenser Containment:
  - **1/3 Smaller**
  - **More like a BWR Drywell**

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Success Started This Way…
And Sustained Commitment…

- **Start at the Top- Senior Leadership Team**
  - Must be First Communication
  - Management Commitment to Change Process
- **Benchmarked and <u>Exactly Replicated</u> Successful Solution**
  - Key: Replicate what worked
- **Engaged a Collaborative Team Process**
  - Outage Management, Operations, Radiation Protection and Chemistry
  - Challenge to Overcome Industry Chemists Objections
    - Requirements to Protect Intellectual Property & Technology Innovation
    - Prevents Detailed Disclosure of “How” Technology Works
    - Decision must be on Safety and Performance Data
- **Senior Executive Leadership Team Made Decision to Implement**
  - RP In Lead Role- Very Important (We own Performance Metrics)
  - Operations, Chemistry and Outage Management Interfaces Required

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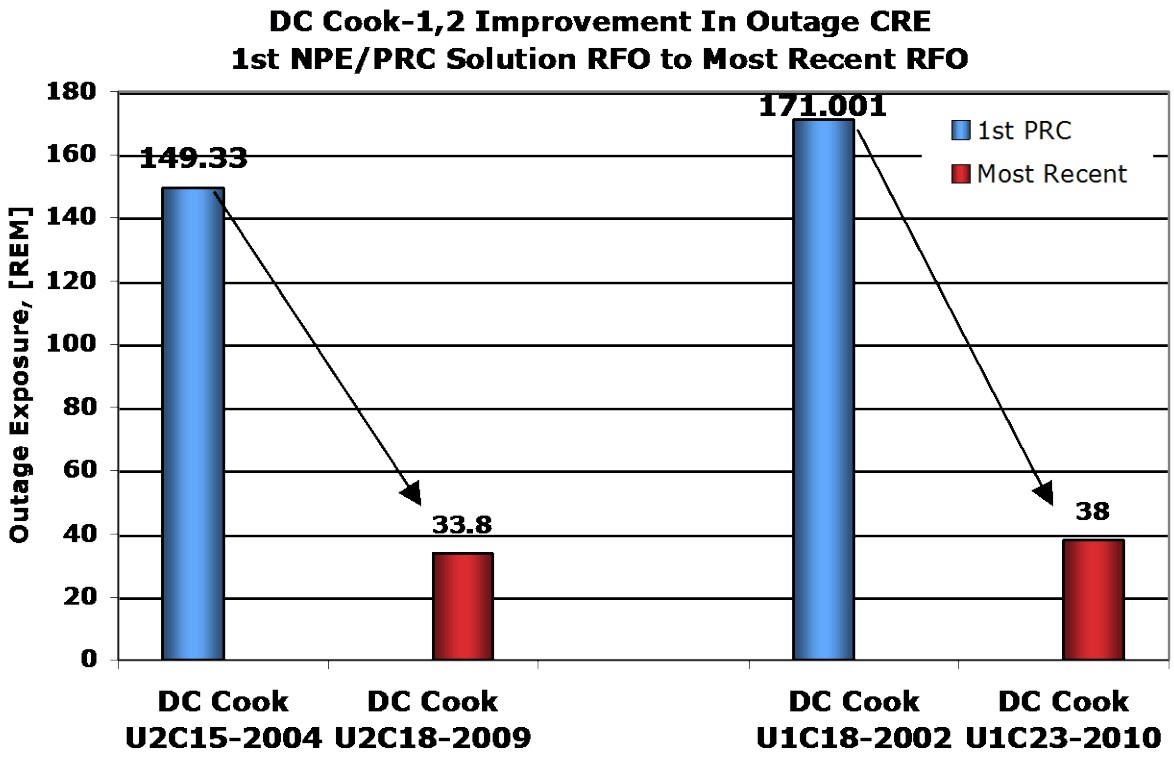
Prerequisites for Low Dose Outages

- **Leadership Team and Organizational Accountability**
  - Must be committed to holding entire organization accountable for results
- **Good ALARA Program**
  - Not all plant exposure is from transport, deposition of colloids
  - Work Management is also important
- **Reactor Coolant Cycle Chemistry**
  - Must Be Monitored And Maintained to EPRI Guidelines
- **Foreign Material Exclusion Program Must Be Excellent**
  - Perfection Is The Goal!!!
- **Clean-Up Systems MUST BE MAINTAINED in Top Condition**
  - Equipment MUST be maintained, tested and in top condition PRIOR to outages

DC Cook-1,2

Most Recent Refueling Outage Collective Radiation Exposure

- **DC Cook-1,2**
  - 2C18: 33.8 REM **US Record** 4 Loop IC Low Dose
  - 1C23: 37.0 REM 35 day
- **5 Year ALARA Plan- 2010-2015**
  - Goal: 15 to 25 REM, 30 day RFOs



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Key to Success - Benchmark +++
Understand Differences, Implement What Worked

Benchmarked Other Stations for <u>Cost Effective Solution</u>

- VC Summer, Turkey Point 3,4

- **What did and didn't they do that was Different?**
- **Did not use:**
  - Zinc Injection
  - Ortho-macroporous resin
  - Fuel Cleaning or Decontamination Technologies
  - Did Not have RTD Lines around Steam Generators
- **Did Use:**
  - Revised Shutdown and Start-Up Protocol from Technology Supplier
  - Use PRC-01M Media in CVCS and SFP
  - Sustained Both Protocol and PRC-01M for 4 Refueling Outages
- **Cook Started a Program to Duplicate What Other Successful Plants Did in Every Detail**

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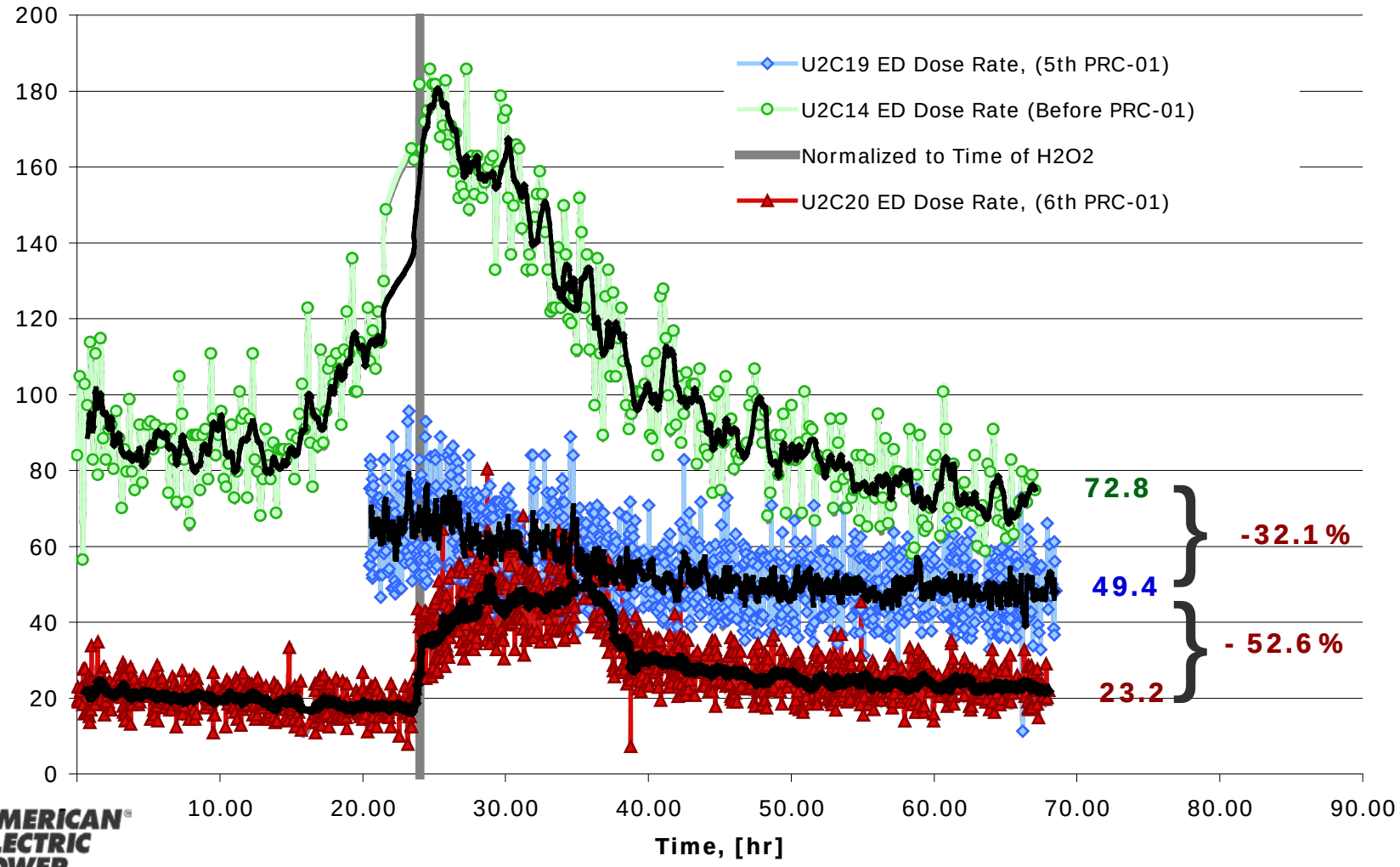
Effective Source Term Results

Achieved Through Implemented Proprietary 2 Part Engineered Solution



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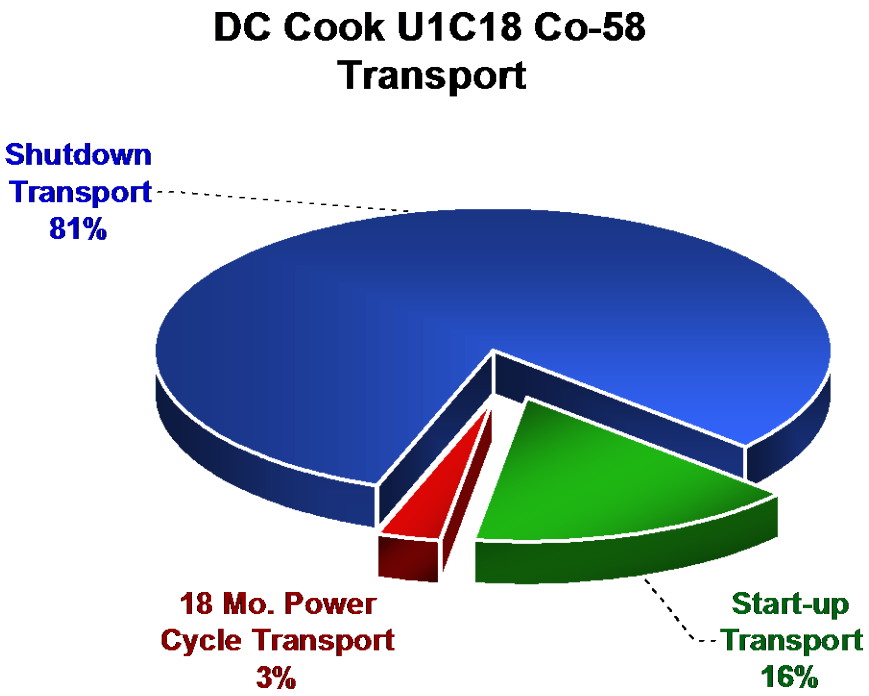
Opportunity for Source Term Mitigation

Shutdown and Start-Up !



- **What?**
  - Remove All Transporting CRUD
  - Not just Co-58 and Co-60
  - Colloids, Iron, Nickel
- **When?**
  - ***81%*** of Transport Occurs at Shutdown
  - Must Focus on Shutdown
  - ALSO!!! Focus on Start-Up
- **How?**
  - Engineered Solution
  - Control Shutdown
    - Preventing Plate-Out
  - PRC-01 Media Technology in Shutdown Demineralizer (this is an important engineered solution)

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Eliminating Confusion:
Assessing PRC-01 Technology Innovation
Shutdown Clean-Up Demineralizer Performance

- ***Before:*** **PRC-01 Resin, DC Cook-2C14**
  - Co-58 and Co-60 DFs > 1,000: 99.9 % Efficient
- ***After:*** **PRC-01 Resin, DC Cook- 2C20, Resin and with Engineered Solution**
  - Co-58 and Co-60 DFs > 1,000: 99.9 % Efficient
- **After 2 Part Engineered Solution Implemented:**
  - **Results: System Dose Rates Have Declined: 68%**

- **CONCLUSION:**
  - Cannot Use CVCS Demineralizer Decontamination Factor (DF) as measure of technology innovation success
  - MUST USE RP METRICS – dose rates, trend data, Collective Radiation Exposure

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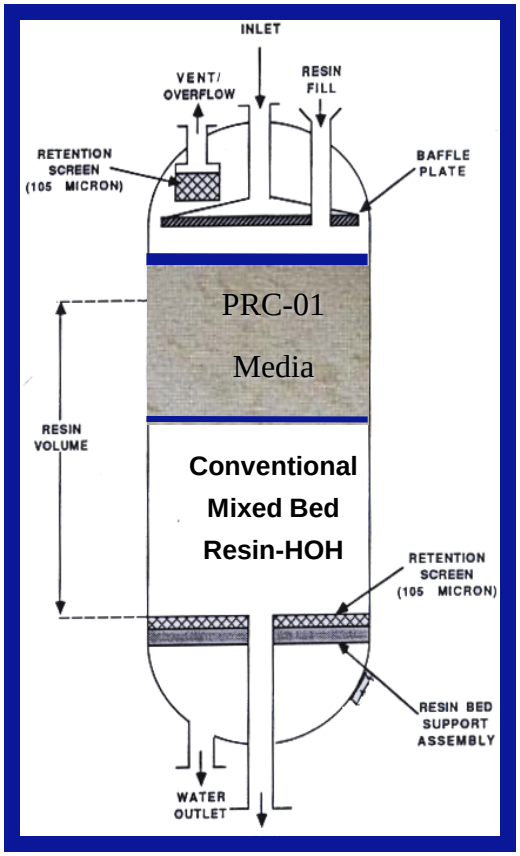
Benchmark: Technology Innovation

Used Correctly, Key to Success



PWR
Deep Bed Vessel

- **Two Part Engineered Solution:**
  - Shutdown/Start-Up Protocol
  - Improved Outage Schedule
- **CVCS Clean-Up Systme Changes:**
  - 1 um RCS Filter Placed In-Service
  - PRC-01 Overlay On top of Conventional Resin
  - Shutdown Bed Discharged and Re-Loaded for Start-Up
  - PRC-01M Spent Fuel Pool

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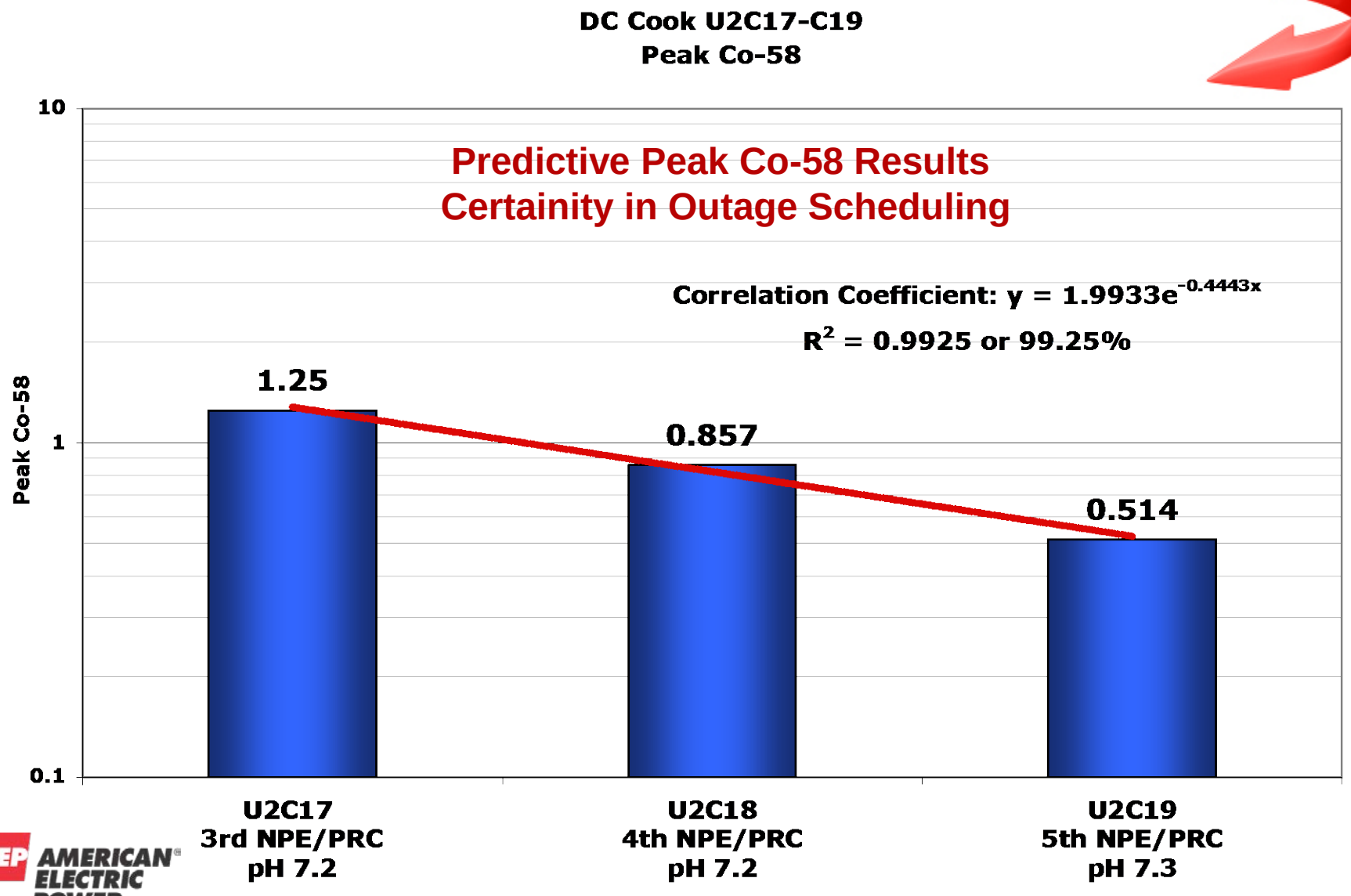
Cook Unit 2: Co-58 Peak Decline with PRC

Correlating Coefficient: 99.25%



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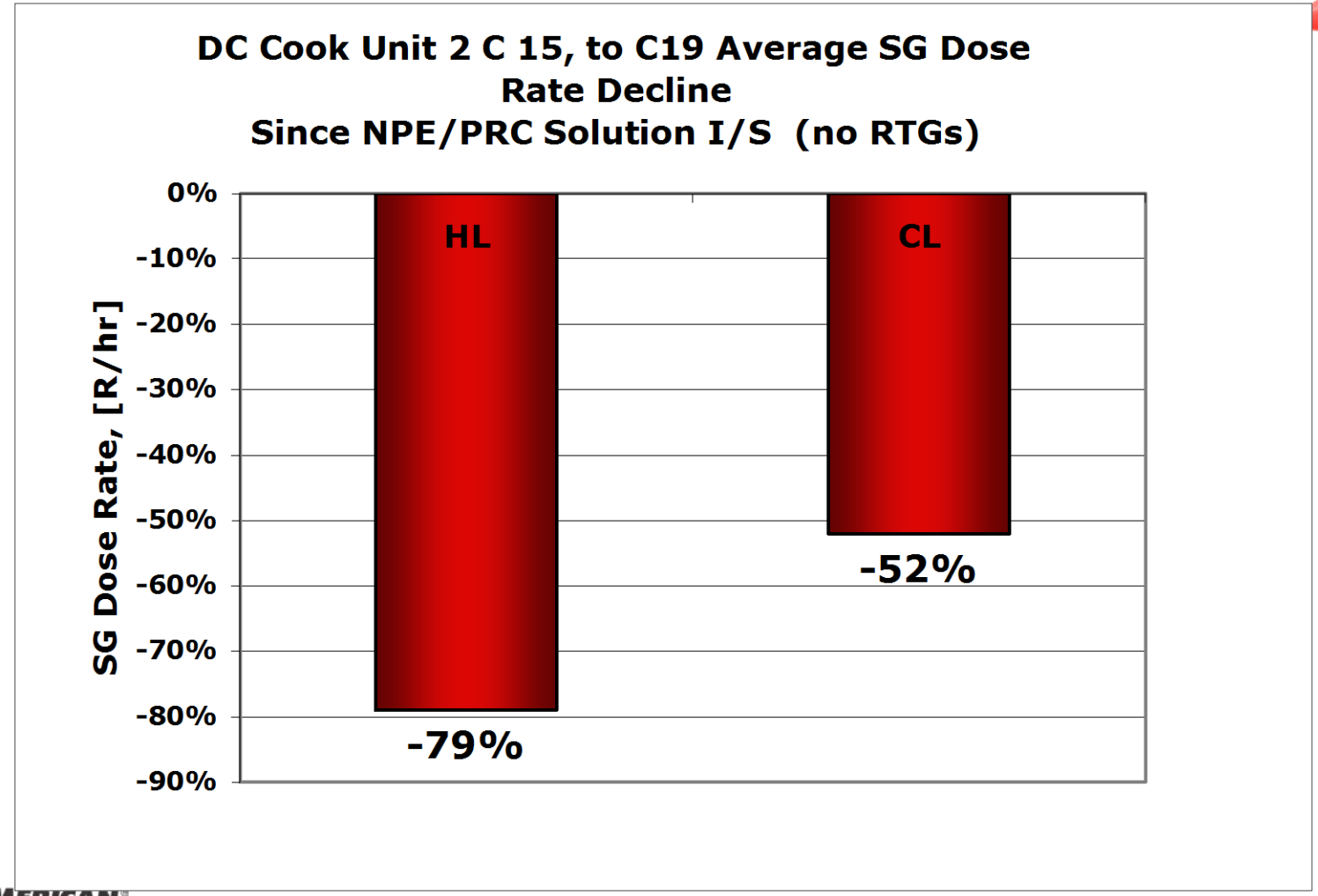
DC Cook Unit 2 SG Dose Rate Change

Between 2C15 and 2C19, 2007 to 2010 (no RTDs)



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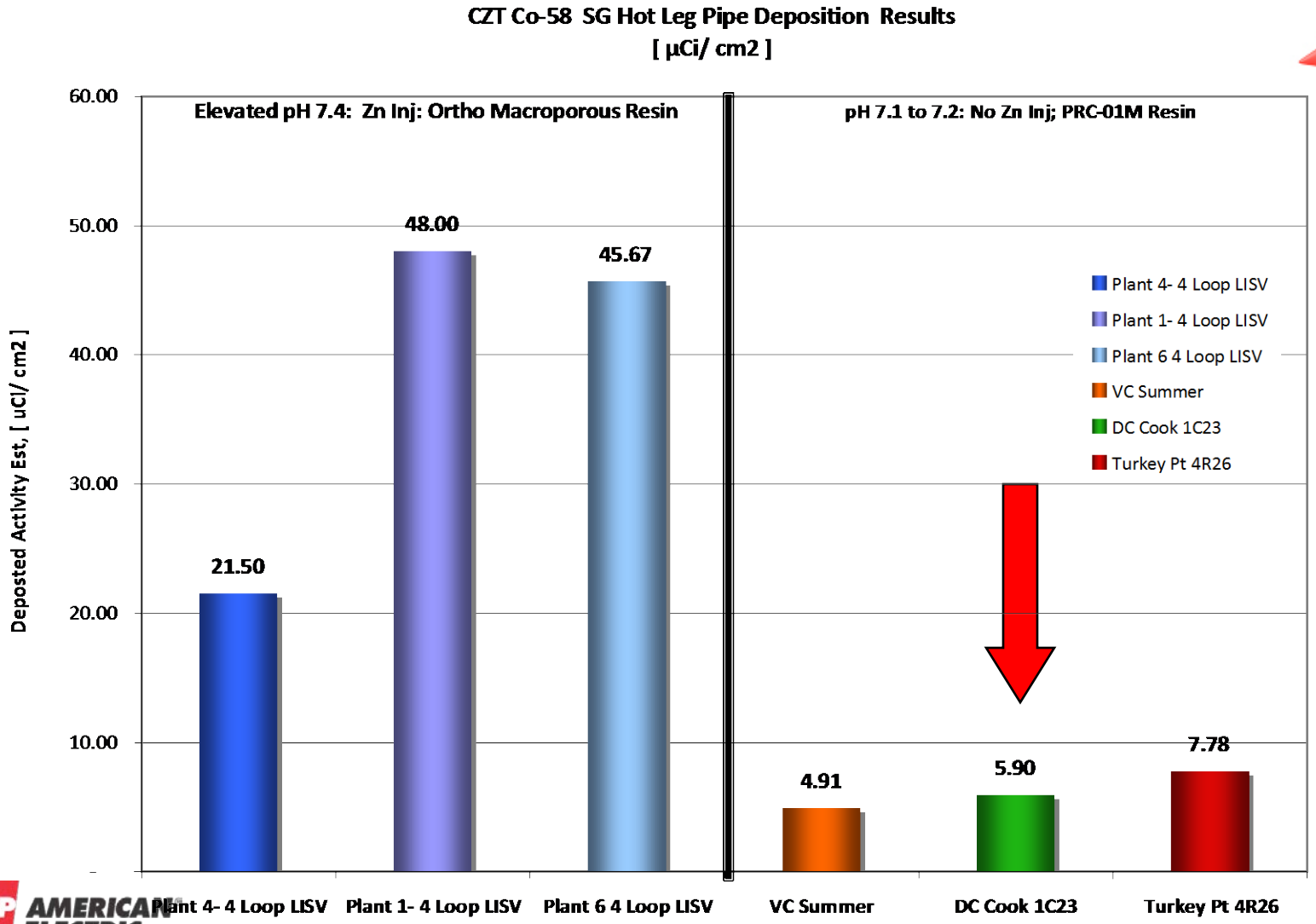
Using New Tools: What is CZT?

Cadmium Zinc Telluride (CZT) Gamma Spectroscopy

- **New Gamma Spectroscopy Technology –** **very important when mix is changing**
  - Identifies Isotopes in Energies between 100 keV to 1800 keV
  - Isotopes identified:
    - Co-58, Co-60, Ag-110m, Cs-137, Sb-124 &122, Sn-113Cr-51, Fe-59, Mn-54, Zn-65, Zr/Nb-95
- **Small and Lightweight**
- **Portable**
- **Cost Effective**
- **No Cooling Required**
- **Refueling Outages**
  - 2 day Measurement
  - 2 day Analysis
- **Also Used On-line**

CZT Results - Benchmarks

Co-58 SG Hot Leg Piping Deposited Activity



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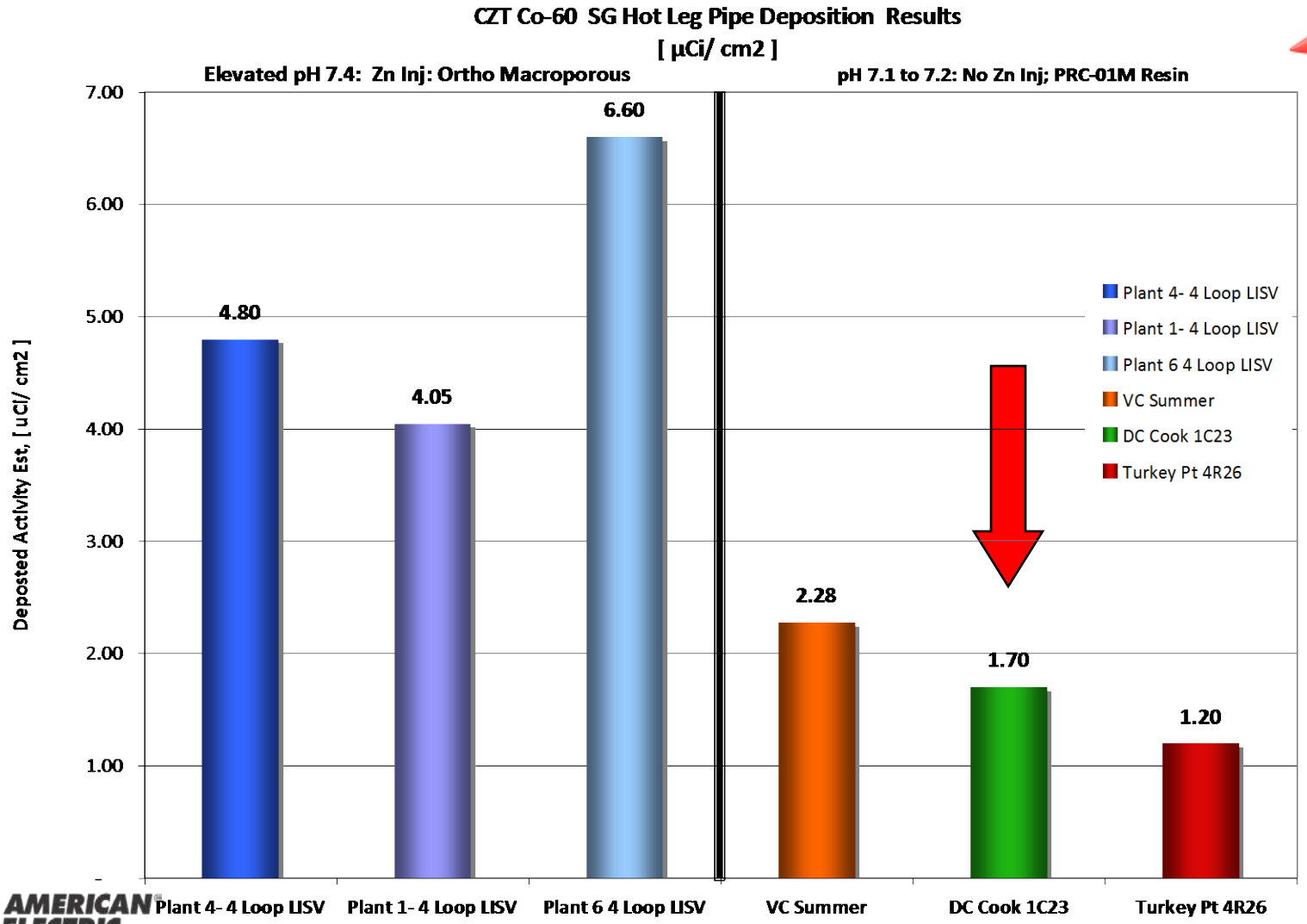
CZT Results - Benchmarks

Co-60 SG Hot Leg Piping Deposited Activity



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How does DC Cook Continue to Improve?

Co-60 is Dose Controlling Isotope – but changing???

- **Shutdown/Start-up Practices**
  - Solid PZR Ops to Permit Early Peroxide Add, +18 vs +30 Hr
  - Live Aggressively to Schedule, Shorter Time with High Activity RCS Less Dose, Work Window Opens
  - Change Nothing Else!
- **ALARA Stays Aggressive**
  - Resist Temptation to Reduce High Standards of ALARA Program as Dose Rates Continue to Drop (this is important)
  - Identify Local Challenge Areas- Involve Experts
  - CZT Technology Provides DATA to Guide us to New Opportunities for Improvement

How does DC Cook Continue to Improve? Co-60 is Dose Controlling Isotope – but changing???

Nuclide	Activity [uCi/cc]	Error%
Mn-54	2.65 E-04	25.01
Co-60	3.87 E-02	0.40

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How does DC Cook Continue to Improve? Co-60 is Dose Controlling Isotope – but changing???

Nuclide	Activity [uCi/cc]	Error%
Mn-54	2.02 E-04	6.45
Co-58	1.64 E-04	6.88
Co-60	2.42 E-04	4.76
Zr-95	1.83 E-02	0.64
Nb-95	3.80 E-02	0.42
Sn-113	1.21 E-03	4.22
Sb-125	1.98 E-03	6.50

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How does DC Cook Continue to Improve? Co-60 is Dose Controlling Isotope – but changing???

- **Co-58/60 Historically predominant isotopes in discrete particles**
  - This has been changing gradually since PRC-01 resin use and cleanup strategies implemented
- **Zr/Nb-95 Becoming More Predominant**
  - Co-60 becoming less and less predominant
  - Trending being performed to predict longer-term impact
- **Electronic Dosimeter to TLD comparison ratios may be changing**
  - Also performing trending on this

What does Future Source Term Look Like?

- **Our Future: 5 Yr Plan**
  - DC Cook-U1 and U2
  - Near Future: >15 to <25 REM RFO
  - U2C20 – 40.2 rem
    - ~10 rem for 100% Eddie Current Testing
    - 30.2 for the rest
    - 3-5 rem reduction easily identifiable from U2C20
- **Your Future…???**
  - “Let Success Do the Thinking”
- **The Data/Results Are There, Don’t Guess Anymore**

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What Does Future for Worker Occupational Exposure Look Like?

- **Future?**
  - Continue Current Source Term Reduction Efforts
  - Improve Dose Ownership In Entire Plant Organization
  - More to come on this…

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