Source Term

Review of Industry Monitoring and Reduction Practices

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2016 North American ISOE ALARA Symposium
January 12, 2016

Radiation Management & Source Term Technical Strategy Group (RMST TSG)

Global experience base of 20 utilities with 74 sites and 166 units (~40% of global fleet) for:

- Benchmarking
  - Quick surveys to emergent issues
  - Deeper looks at topics of general interest
- Independent objective technical assessments (3002005484)
- Answering tactical research questions
  - PWR shutdown releases (3002005483)
  - BWR ultrasonic fuel cleaning as radiation field reduction strategy (3002005482)
  - Radiation Field modeling – OSCAR
  - Radiation Monitoring Technology Implementation Guidance (3002005480)
- Exchange
  - Annual Workshops (with associated learning opportunities)
    Shielding & Scaffolding – June Remote Monitoring – August
    Radiation Field & Source Term Reduction – September

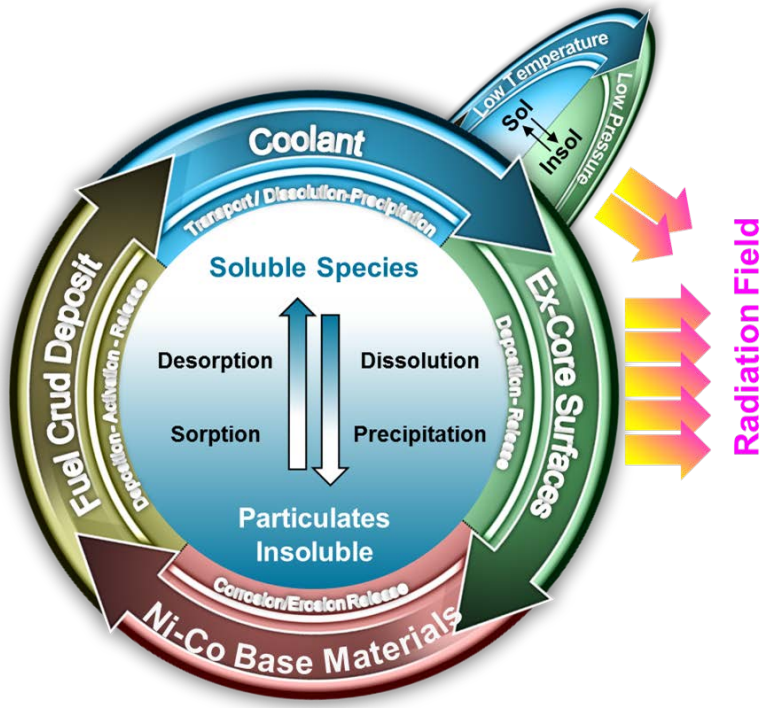
Global Industry Peer Group

RMST TSG – 2016 Membership

Utility - Membership period		2014-2016	2015-2017	2016-2018
Dominion Resources Inc. 3 (6)	Dominion			TBF
AXPO – 2(3)	NOK	x		
Comision Federal de Electricidad 1 (2)	CFE	x		
Detroit Edison 1 (1)	DTE Energy	x		
Electricite de France 19 (58)	EDF	x		
FirstEnergy Service Company 3 (4)	FENOC	x		
Korean Hydro Nuclear Power 6 (23)	KHNP	x		
Luminant 1 (2)	Luminant	x		
NA-SA 1 (3)	NA-SA	x		
Nebraska Public Power District 1 (1)	NPPD	x		
Public Service Electric and Gas 2 (3)	PSE&G	x		
Southern Company 3 (6)		x		
Tennessee Valley Authority 3 (6)	**TVA**	x		
Xcel 1 (3)		x		
Arizona Public Service (Palo Verde) – 1 (3)	APS		x	
Energy Northwest* 1 (1)			x	
Entergy Services, Inc. 8 (10)	Entergy		x	
Duke Energy 4 (11)	Duke			x
Exelon Corporation 13 (22)	Exelon			x
Omaha Public Power District 1 (1)	OPPD			x

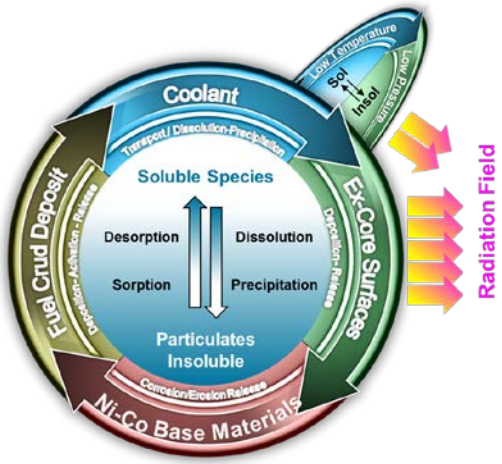
Not seeing your utility – Consider joining – Speak to your NMETT

Source Term - Owners and Reduction Drivers



- Who selects replacement materials?
- Who decides on core and fuel design?
- Who decides on the water chemistry regime?
- Who operates the coolant cleanup?
- ….

Source Term - Owners and Reduction Drivers



Source Term is controlled and affected by all departments

Source Term reduction is most effectively achieved, when all department have the same objective:

Producing power, cost efficient, while source term conscious

Review of Industry Source Term Reduction

- Objective:
  - Identify best practices & lessons learned
  - Identify knowledge gaps and technology needs

- General Observation:

Do not expect Quick Fixes – Source Term Reduction manifests successes after several cycles

- Basis:
  - Past EPRI Source Term Assessments
    More than 20 assessments performed globally
    - ~ 2/3 BWR
    - ~ 1/3 PWR
    - several repeat assessments
    - a couple non-U.S.

TSG report 3002005484 - October 2015

Source Term Reduction in Pressurized Water Reactors

- Beneficial source term strategies identified are:
  - Fuel cleaning
  - Zinc chemistry
  - Elevated lithium control programs
  - Crud mitigation
  - End-of-cycle chemistry control strategies

- Gaps – future research
  - Develop better understanding and guidance on
    - Optimum time to terminate zinc feed prior to EOC considering Zn ions impact on ex-core surface deposition
    - Changing lithium/pH_T during the latter portion of a cycle (within Guideline limits) to stabilize fuel deposits (and minimize deposition on ex-core surfaces)

Source Term Reduction in Boiling Water Reactors

- Common issues found
  - Materials (Stellite™ replacements and material specification/verification)
  - RWCU and RHR materials – carbon steel surfaces generally cause higher radiation fields than stainless steel surfaces
  - Cleanup system performance and availability

- Factors contributing to source term mobility include
  - Fuel failures
  - Change in core design
  - Condenser inleakage
  - Transients affecting hydrogen-oxygen balance in coolant
  - Sequencing of platinum injection
  - Noble metal application close to outage

Source Term Reduction in Boiling Water Reactors

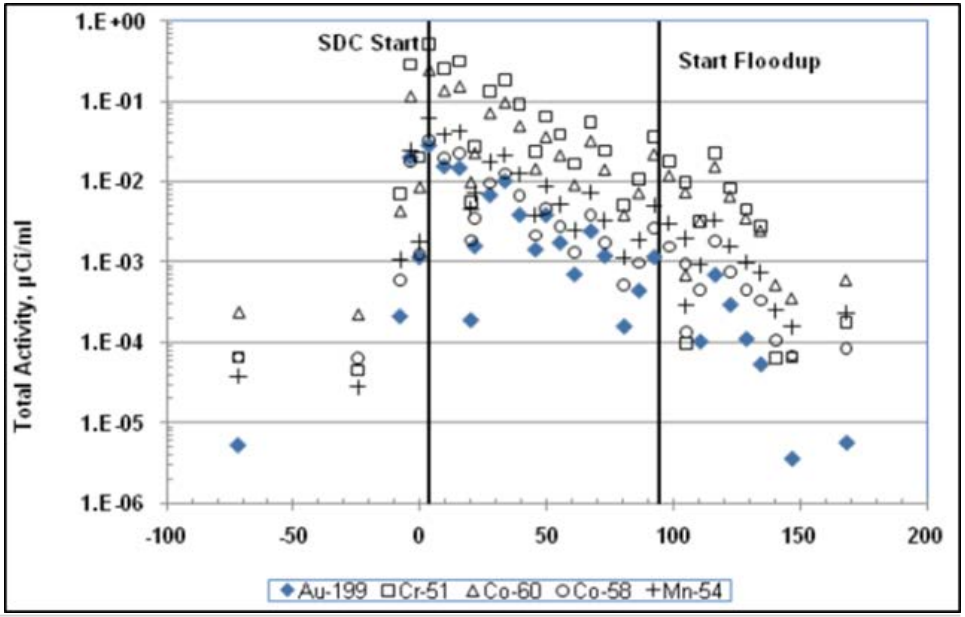
- Beneficial Source Term reduction strategies
  - Reduction of cobalt-containing materials such as Stellite™ (OEM blades, valves…)
  - Excellency in cleanup system performance and availability
  - Optimum chemistry program (HWC, Pt, Zn)
  - Minimize FW iron ingress
  - BWRVIP-225 recommended shutdown practices

- Beneficial outage operational practices
  - Flood up through the condensate treatment system
  - Using submersible filters and demineralizers to supplement cavity cleanup
  - Applying fresh precoats to RWCU F/Ds and fuel pool cooling system F/Ds shortly prior to outage start
  - Maintaining RWCU in service until after cavity floodup is complete, fuel gates are open, and water clarity has been established

Source Term Reduction in Boiling Water Reactors

Gaps – future research

- Chemistry
  - Behavior of chromium and Cr-51 under OLNC, low hydrogen and low iron conditions
  - Impact of OLNC, low iron, and high zinc chemistry on radiation fields
  - Chemical decontamination – sequencing of noble metal application
  - Behavior of reported Zn-65 and Zn-69m relative to elemental zinc levels needs better understanding
- Materials
  - Impact of removal of admiralty brass condensers on copper source – ECP effect and reduction of natural zinc caused radiation field
  - Impact of in-vessel cobalt sources on cobalt mass balance
  - Cr-51 particulate releases
  - Transition to Inconel® grids will this cause an increased contribution from Co-58
- Operations
  - Impact of shutdown practices on hotspots and associated CRE
  - Cleanup of forward pumped drains
- Fuels
  - Influence of core and/or fuel design on source term and its mobility
  - Control rod sequencing impact of activity transport
- RP
  - Chemical decontamination benefit relative to asset protect and recontamination rates
  - Remote monitoring as part of ALARA program



Review of Industry Source Term Reduction

- **Do's**
  - **Component replacement:**
    - **Eliminate high cobalt content materials (Stellite™ etc.)**
    - **Enforce material specifications in regards to cobalt content**
    - **Enhance surface finishes**
  - **Optimize reactor coolant cleanup efficiency and performance**
  - **Limit core crud buildup and carry-over**
  - **Optimize chemistry program**
  - **Use any additional coolant cleanup system during outage**

- Don't's
  - Replace non-Stellite™ with Stellite™
  - Ignore degrading cleanup system performance
  - Ignore chemistry and radiation field monitoring
  - Expect quick fixes

A Decade's Collection of Source Term Reduction Knowledge

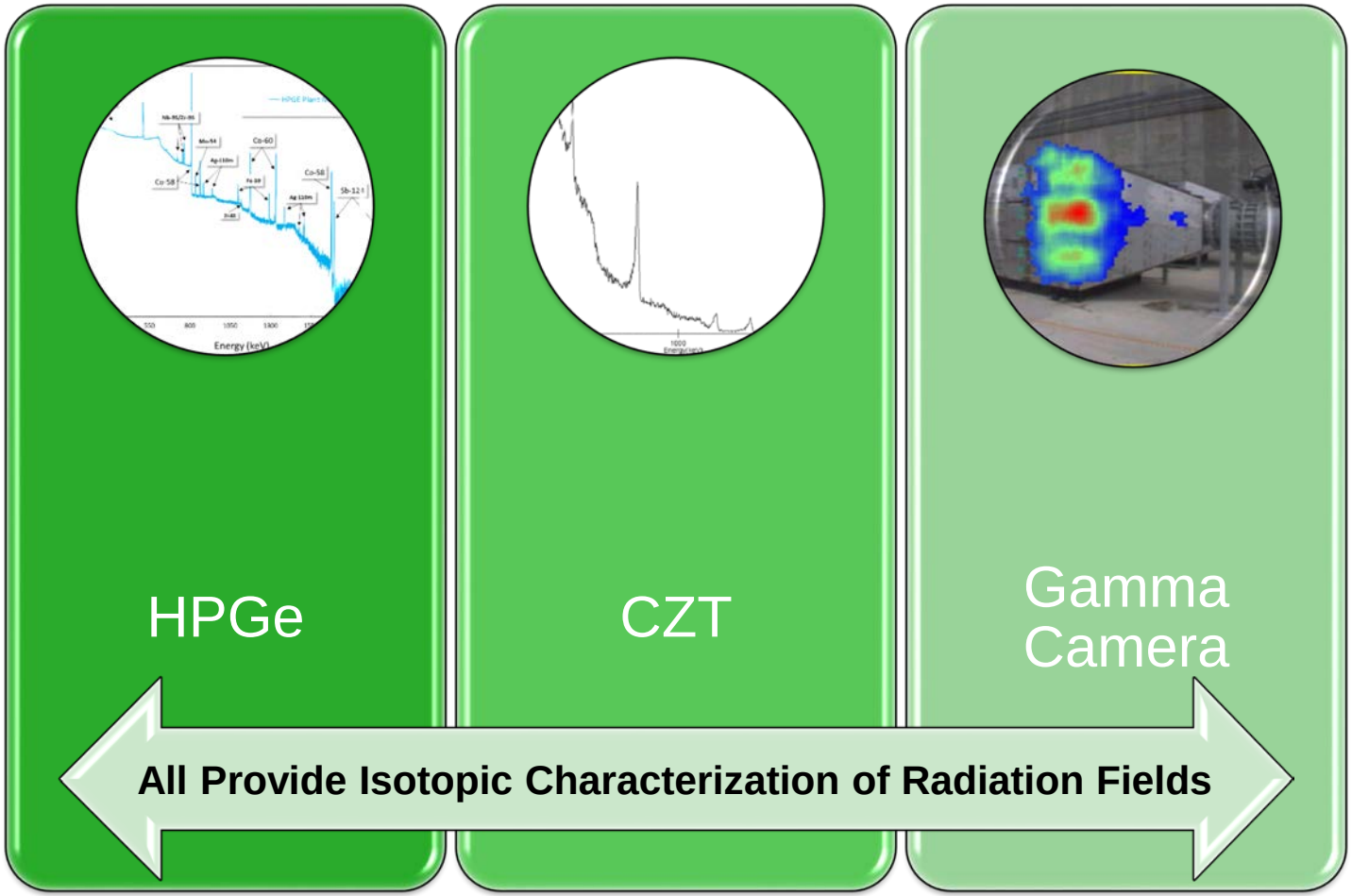
Review of Industry Source Term Isotopic Monitoring

- Objective:
  - Identify best practices & lessons learned
  - Provide guidance on monitoring tool selection
  - Identify knowledge gaps and technology needs

- Basis:
  - Current technological development
  - Past EPRI technical work
  - Global monitoring practices

Radiation Safety report 3002005481 - October 2015

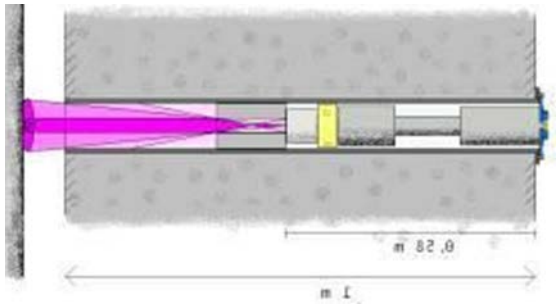
Today's Equipment Choices for Isotopic Source Term Monitoring

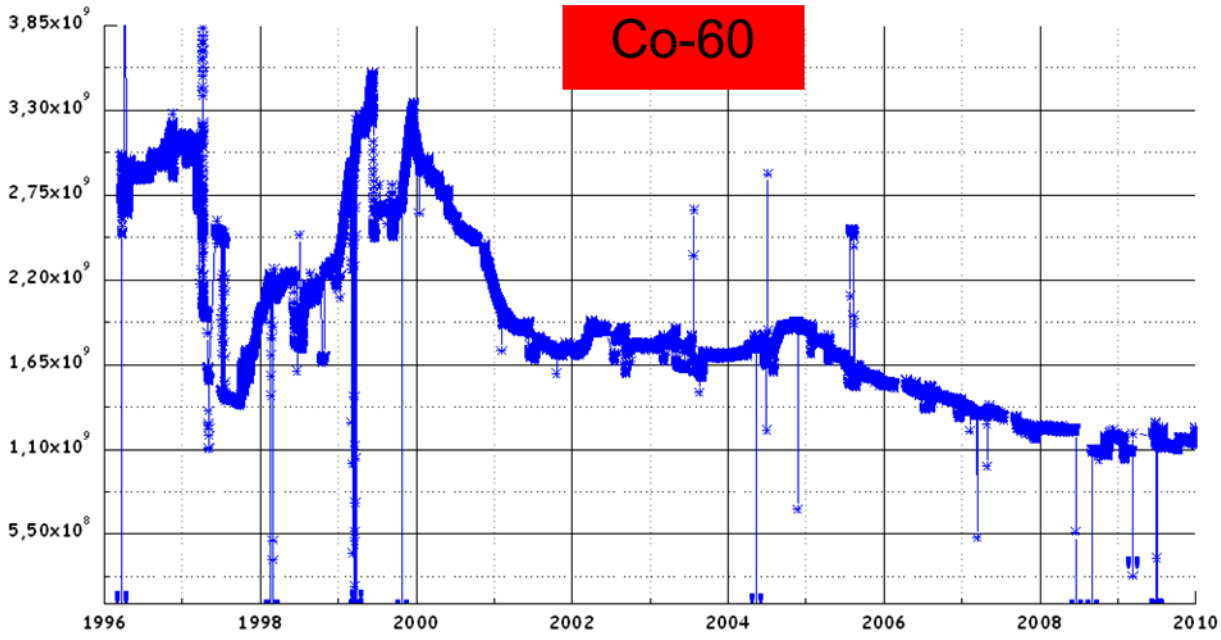


Monitoring Purpose Driven Flowchart Guides Selection

Top Notch Practice - OLA
Online HPGe Monitoring at Ringhals

Co-60 trend is chosen as example, all identified nuclides in gamma spectrum are tracked and trended



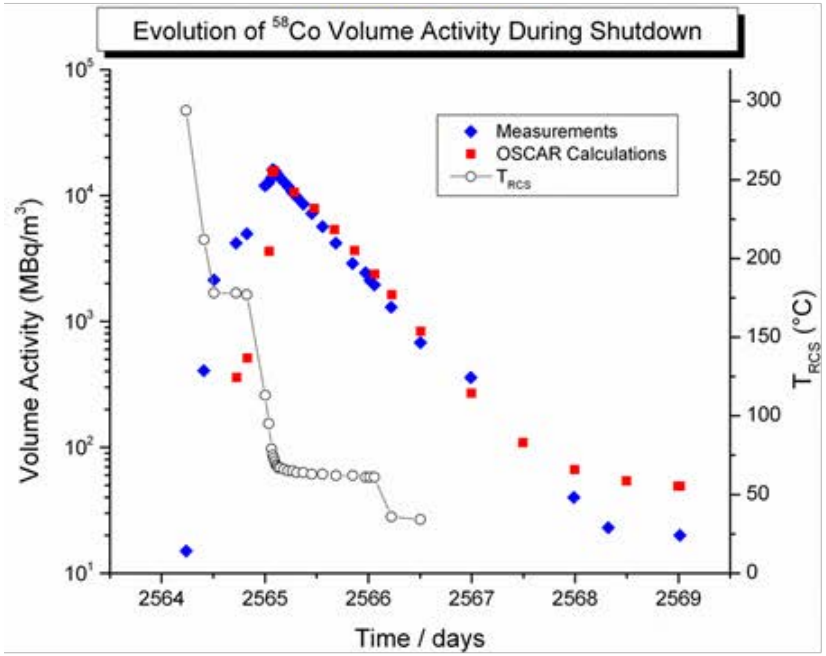


Future
EPRI RMST TSG
Plans

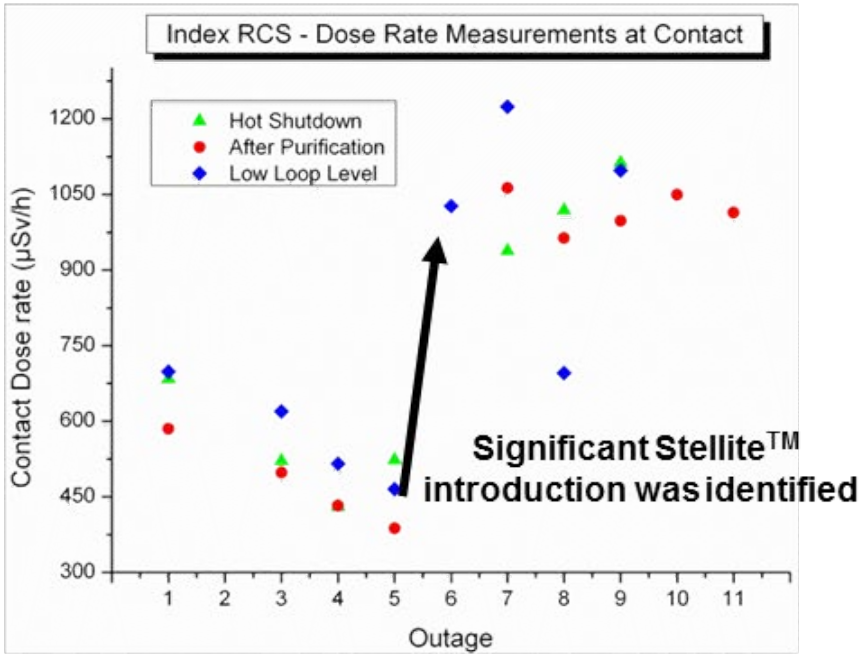
OSCAR – a PWR Radiation Field Modeling Tool

- RMST TSG currently working to bring to EPRI members
- Focus on research, sensitivity, and validation studies
- EPRI and Southern are working on validating OSCARs capabilities

Predictive



Explorative



Mathieu Corbineau, *OSCAR – Modeling Tool for Source Term Management and Dose Reduction: AREVA Use*, 2015 EPRI Source Term and Radiation Field Reduction Workshop, 15 July 2015, Charlotte, NC.

EPRI RMST TSG Meetings in 2016

& knowledge transfer opportunities

- **Dose Reduction for Scaffolding, Insulation, and Shielding Workshop**
  - June 14-16, 2016 in Charlotte, NC at EPRI Offices
- **Radiation Monitoring Technology Workshop**
  - August 2016 – details TBD
- **Radiation Field and Source Term Reduction Workshop**
  - Sept. 12 - 14, 2016 in Charlotte, NC at EPRI Offices
  - Monday afternoon – Utility only – Source Term 101
  - Tue/Wed – open workshop
  - In conjunction with PWR Chemistry TSG – Wed pm joint session
- **In-plant gamma measurement technical foundations training**
  - Sept 15, 2016 at EPRI Charlotte offices
  - open to EPRI members - please email interest to cgregorich@epri.com

For more information, email cgregorich@epri.com

EPRI Projects of Source Term Interest

Base, RMST and PWR Chemistry TSG projects

- Collection of monitoring data – chemistry and radiation field
- Surface passivation
- Micro-Climate
- Silver and Antimony influence on radiation field generation
- Hydrophobic Coatings
- Activity transport modeling review
- Source Term Reduction Sourcebook – Cobalt and beyond
- PWR shutdown release
- RCP operational practices

Visit RadSafety Cockpit on www.epri.com for more information

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