KINECTRICS

GENERATING SUCCESS --- FOR 100 YEARS

Impact of Activity Removal by IX Resins on Outage Radiation Fields

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KINECTRICS

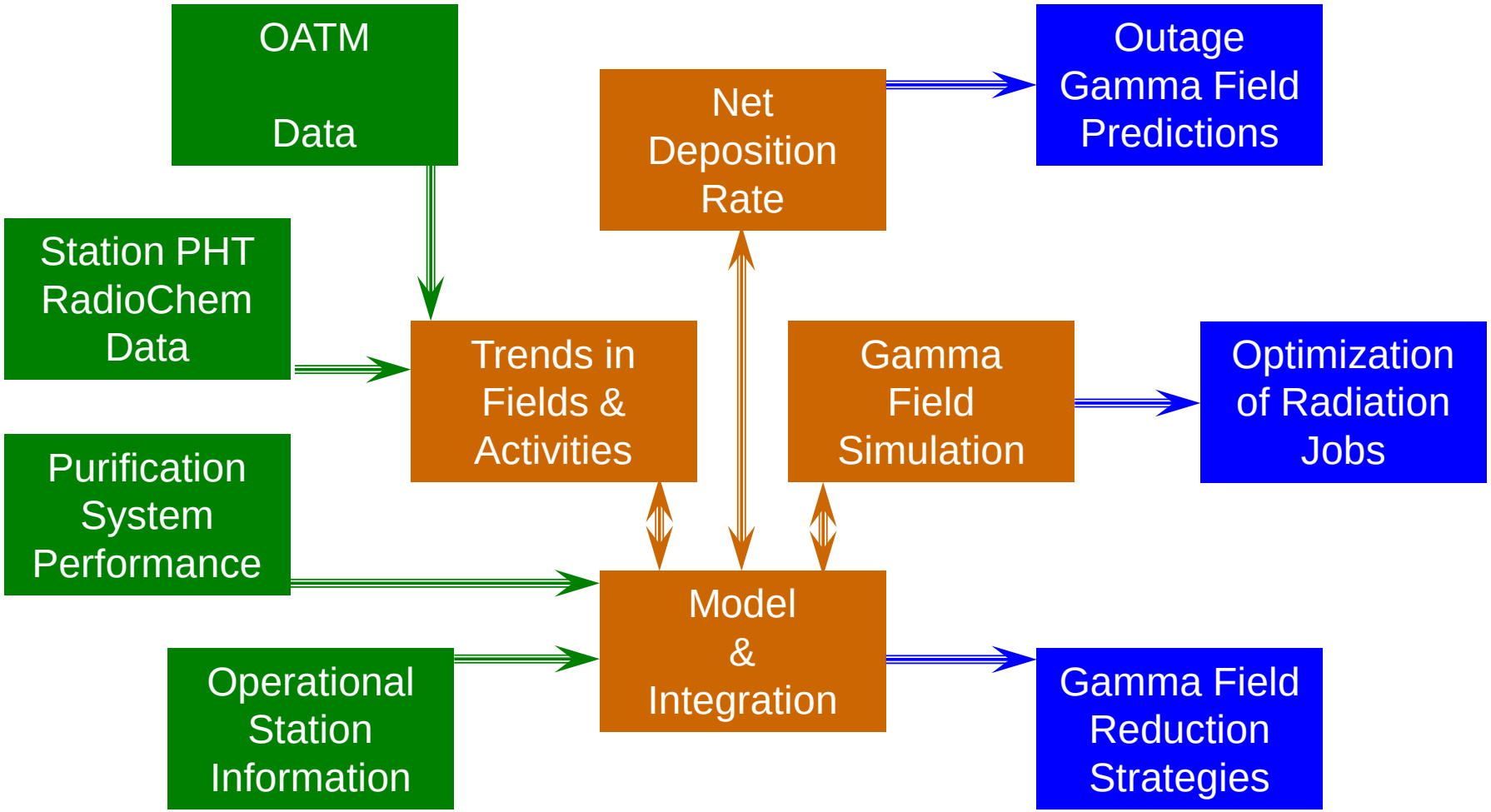
All theory, dear friend, is gray, but the golden tree of life springs ever green.

Quote by Johann Wolfgang von Goethe

Introduction

- Kinectrics Routinely Conducts the Source Term Monitoring at CANDU Fleet. Main Activities include:
  - **O**utage **A**ctivity **T**ransport **M**onitoring Surveys (OATM)
  - Data Integration and Interpretation
  - Radiation Field Trend and Impact Analysis
  - Outage Radiation Field Mapping & Predictions

Data Integration & Interpretation



Outage Radiation Field at CANDU Unit

Main Contributors:

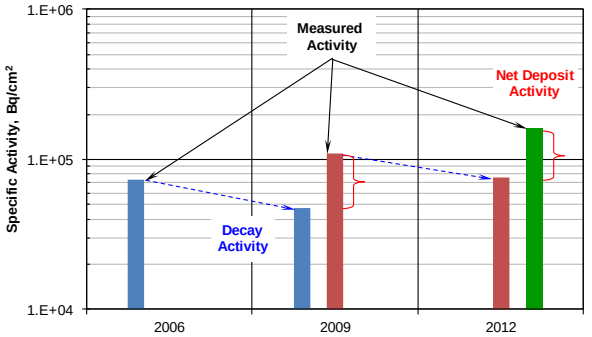
Co-60 (40-80%), Zr/Nb-95 (10-40%), Sb-124 (2-20%) and F.P. (1-10%)

Soluble & Insoluble Contaminants

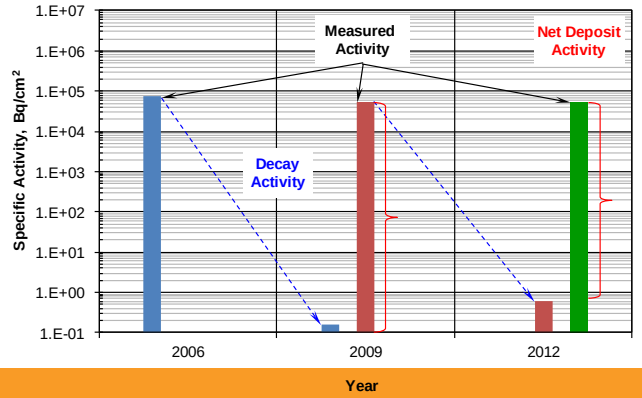
$$RF(r,t) = \sum_i \{f_i(r) \times w_i(t) \times A_i(r,t)\}$$

RF - outage radiation field;
r - distance from the gamma source;
t – time of a particular outage;
i - radionuclide index;
f_i - activity to dose conversion factor;
w_i - impact factor for *i* – radionuclide;
A_i - activity of radionuclide;

Long-lived Radionuclide



Short-lived Radionuclide



PHT Purification System

- System is Designed to:
  - Minimize the Levels of Soluble and Insoluble Impurities
  - Remove Potential Corrosive and Deposit Forming Constituents (such as chlorides, silicates and carbonates)
  - Maintain the Required Heavy Water Chemistry
- System Consists of:
  - 2 Parallel Filters (FR) connected in Series with
  - 4/2 Parallel Ion Exchangers (IX)

Impact of the System on Radiation Field

Radiation Field

Design Data: S, cm^2

OATM Data
Surface Activity:
As, Bq/cm^2
Factor per Year:
k
Net Activity per Year:
$A = S \times As \times k$, Bq

Net Deposited Activity

Purification System

Ion Exchange Resin

Design Data: V, cm^3

Spent IX Resin Scan
Volume Activity:
Av, Bq/cm^3
Total Activity per Year:
$A_{IX} = Av \times V$, Bq

Activity Removed by IX Resin

Fine Removal Filter

Design Data: S, cm^2

Spent FR Filter Scan
Surface Activity:
Av, Bq/cm^2
Total Activity per Year:
$A_{FR} = A_S \times S$, Bq

Activity Removed by Filter

Activity Removal by IX Resin: Methodology

Total radionuclide activities at the end of service period for the IX Resin:

$$A_{IX}^{i} = a_{C}^{i} \times r \times \varepsilon_{IX}^{i} \times \int_{0}^{T} e^{-\lambda_i t}\, dt$$

A_{IX}^{i}	Total radionuclide activity in the spent IX resin (Bq) at the end of service period;
a_{C}^{i}	Average activity of the radionuclide (*i*) in the coolant during IX column service duration (Bq/kg);
r	Average bleed flow rate (kg/sec) through the IX column during its in-service period;
T	IX column in-service duration (sec);
ε_{IX}^{i}	Effectiveness of the IX column in removing the radionuclide of interest;
λ_i	Radioactive decay of radionuclide of interest

Measured total radionuclide activities:

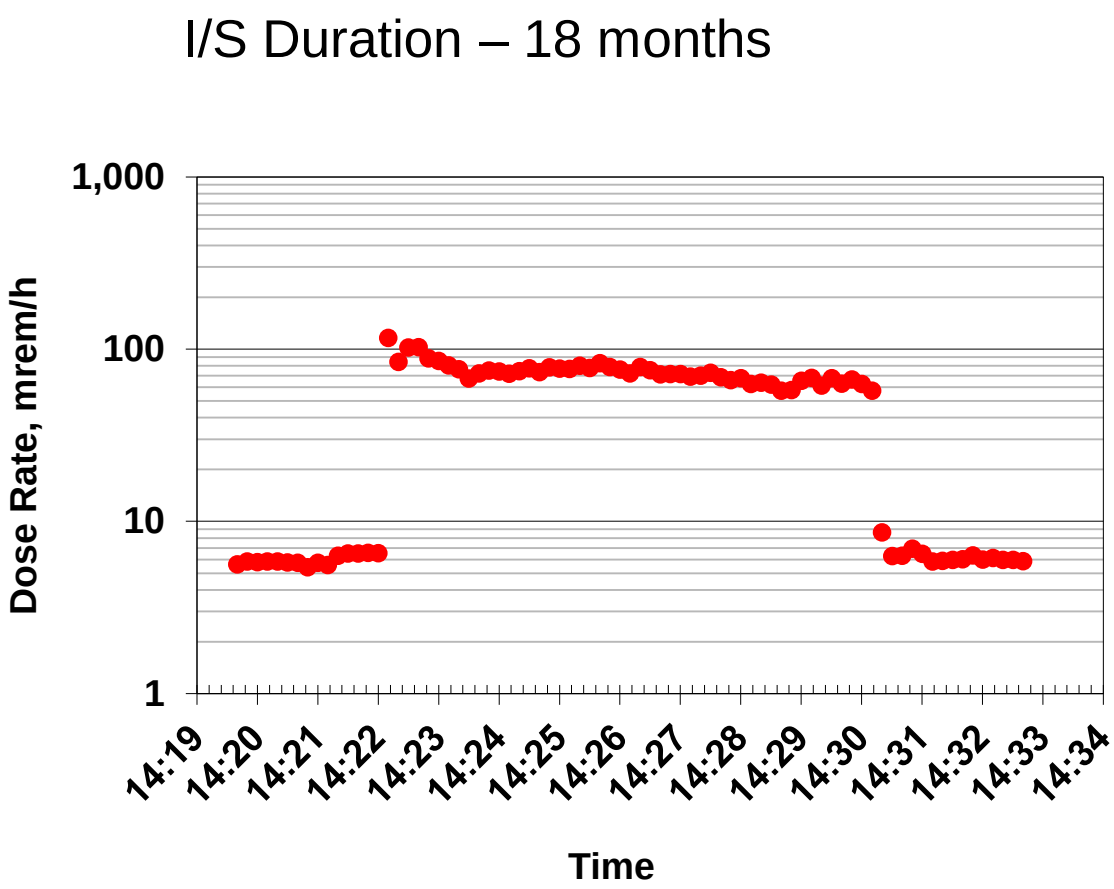
$$A_{IX}^{i} = a^{i} \times V_{IX}$$

Resin Effectiveness for the radionuclide of interest:

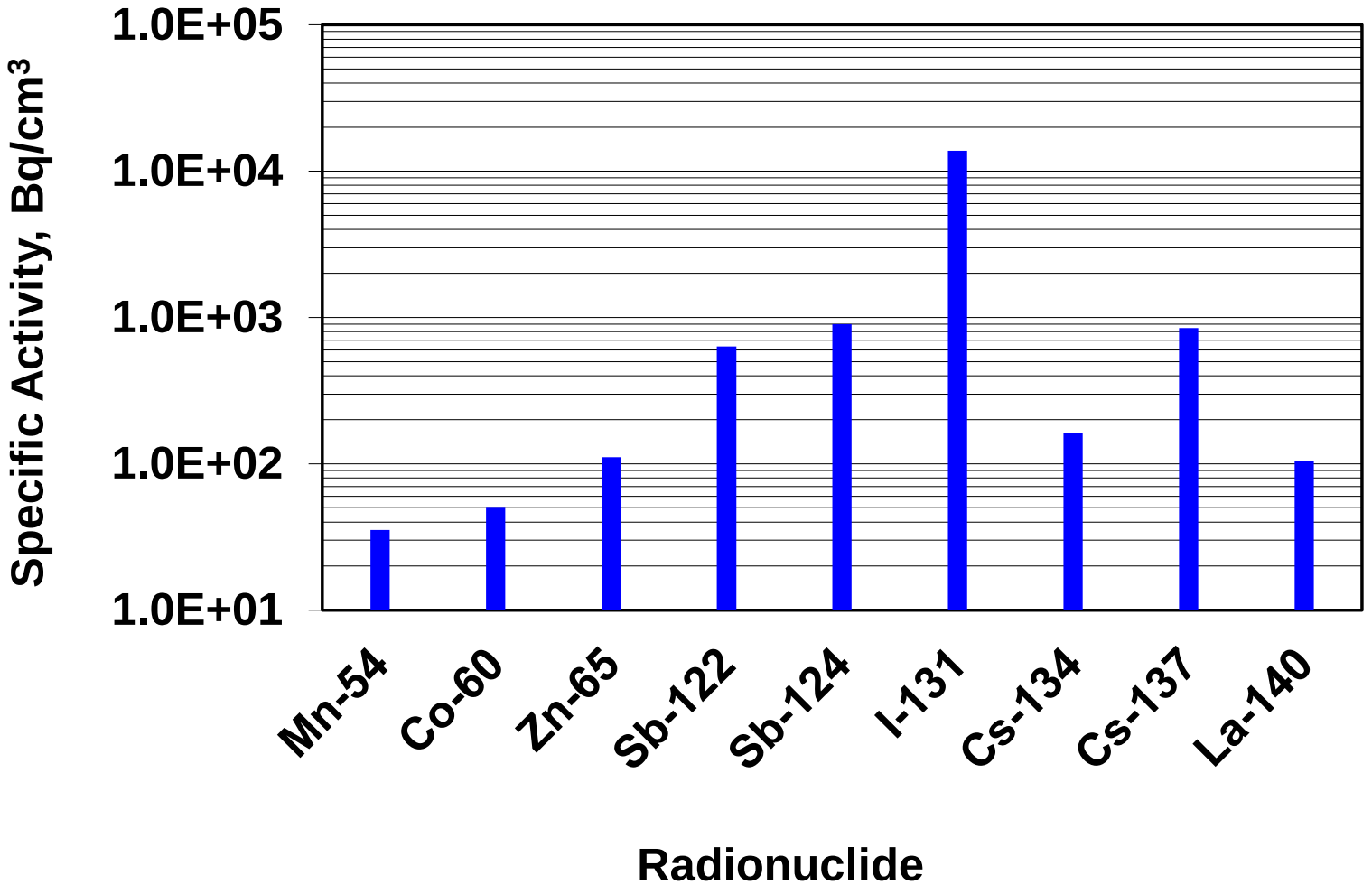
$$\varepsilon_{IX}^{i} = \frac{a^{i} \times V_{IX} \times \lambda}{a_{C}^{i} \times r \times \left(1 - e^{-\lambda T}\right)}$$

In-Situ Spectrometry of Spent IX Resin

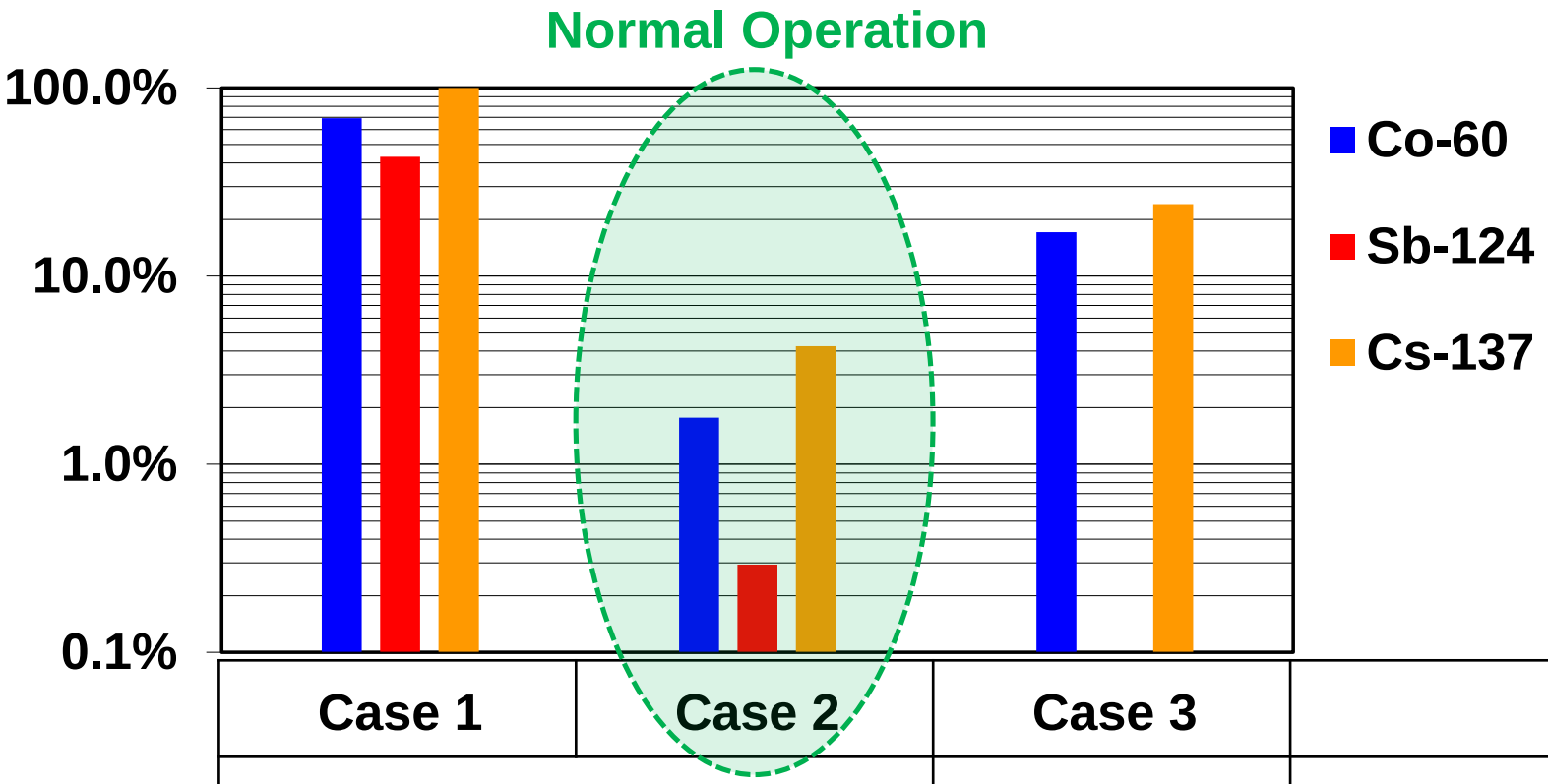
Survey during Spent Resin Slurry from the System to the Waste Tank



Spent IX Resin: Radionuclide Distribution



Effectiveness of Radionuclide Removal



Case 1	Case 2	Case 3	
A		B/Field Trial	Resin ID
< 10 d	~ 600 d	~ 600 d	Service Duration

Conclusions

- Convenient Approach for Performance Analysis of Purification System
- Database of the Radionuclide Distributions and Inventory for IX & FR will allow:
  - Analyze the Effect of Mechanical Filter Parameters (pore size, media) based on the Actual Station Data
  - Directly Correlate the Activity Data to the Unit Service Conditions
  - Compare the Performance of Various IX Resin Types
  - Analyze the Radionuclide Distributions between IX Resin and Filter Media