KINECTRICS

Source Term Reduction via Activity Releases during CANDU® Unit Outages

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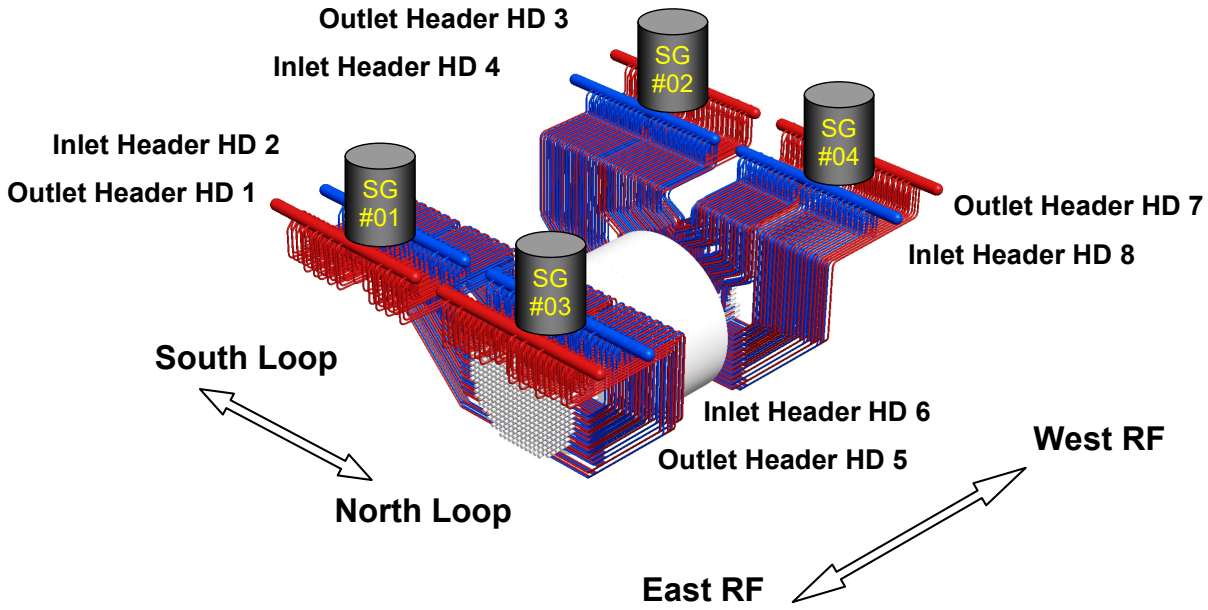
Background: Outage Radiation Fields

Reactor Unit:

- 480 Fuel Channels, On-Power Refueling
- Outages every 2-3 years
- Out-of-core Surfaces (Steam Generators ~ 17,000 m^2 & Feeders ~ 3,000 m^2) in the PHT System covered by magnetite layer

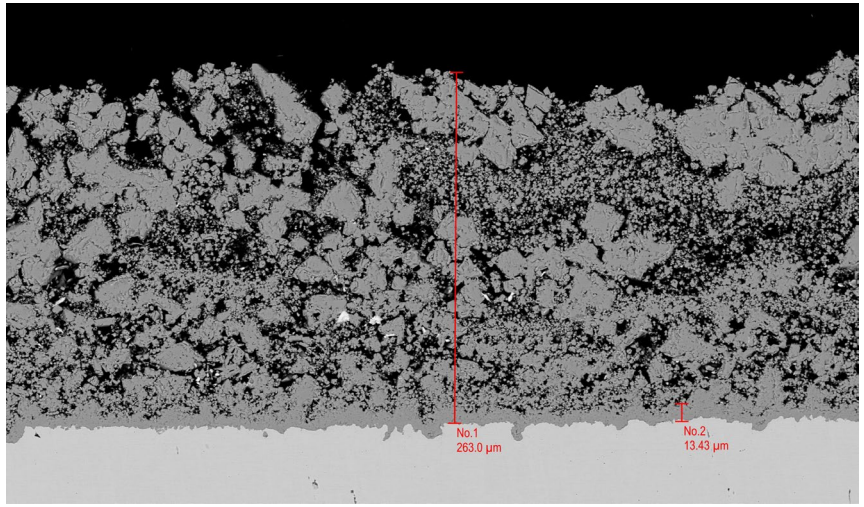


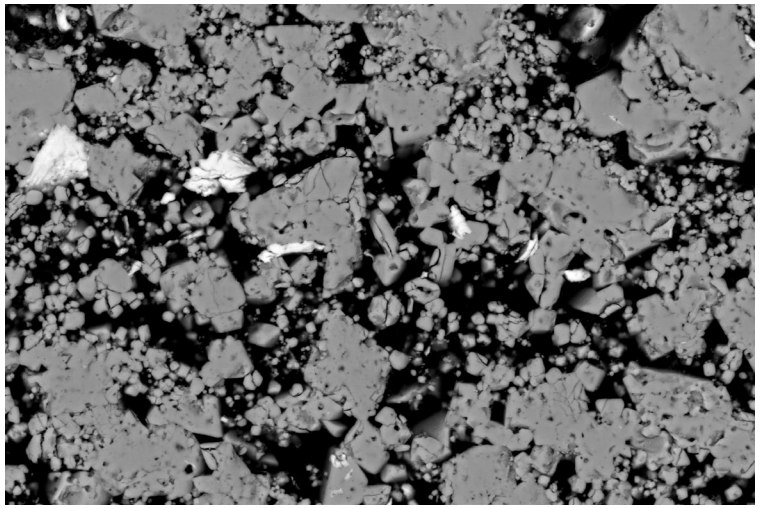
Outage Radiation Fields:

- Radionuclides deposit into the magnetite layer
- Main radiation source in the reactor vault – Feeder pipes
- Major Dose Contributors: Co-60 (40-80%), Zr/Nb-95 (10-40%), Sb-124 (2-20%); FP (1-10%)

Background: Feeder Deposits

- The purpose of a controlled pH_a lowering during a unit outage is to release some of the magnetite containing radionuclides from the inner surface of the feeders in order to decrease the radiation fields in the vault and feeder cabinets.
  - ✓ PHT system is in Low Level Drain state;
  - ✓ Target pH_a value ~ 7





SEM-EDS analysis

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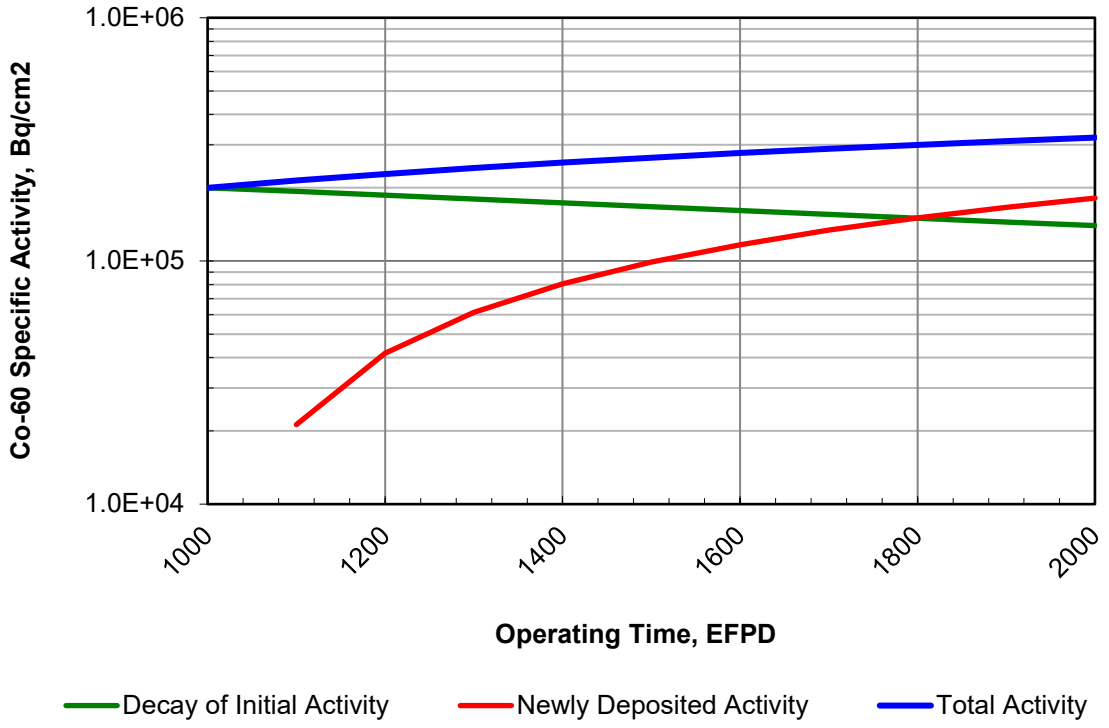
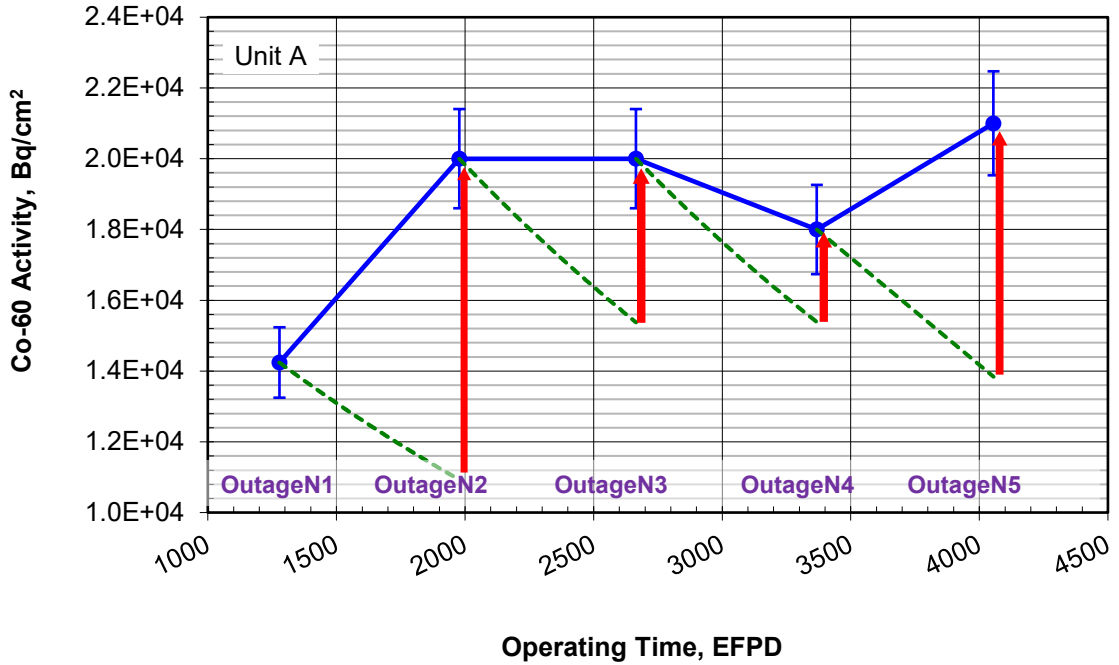
Background: Co-60 Activity Trends





Newly Deposited Co-60 Activity >
Main Target of Activity Release during the Unit Outage

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iSTM (**i**ntegrated **S**ource **T**erm **M**onitoring) Program

Novel and First-of-its-Kind Program Specifically Developed for CANDU Units

Main elements include:

- **O**utage **A**ctivity **T**ransport **M**onitoring Surveys (OATM)
- Review of Unit-Specific Operational Data (SCRs, chemistry parameters, bleed flow rates, etc.)
- Outage Radiation Field and Activity Trend Analysis
- Next Outage Radiation Field Predictions
- Characterization of Purification Components / Crud / Deposits / Reactor Artefacts
- Integrated Analysis of Unit Service/Operational Conditions and System Performance
- Online Monitoring of Gamma Activity during Unit Outage and Operation
- Source Term (ST) Factors Analysis

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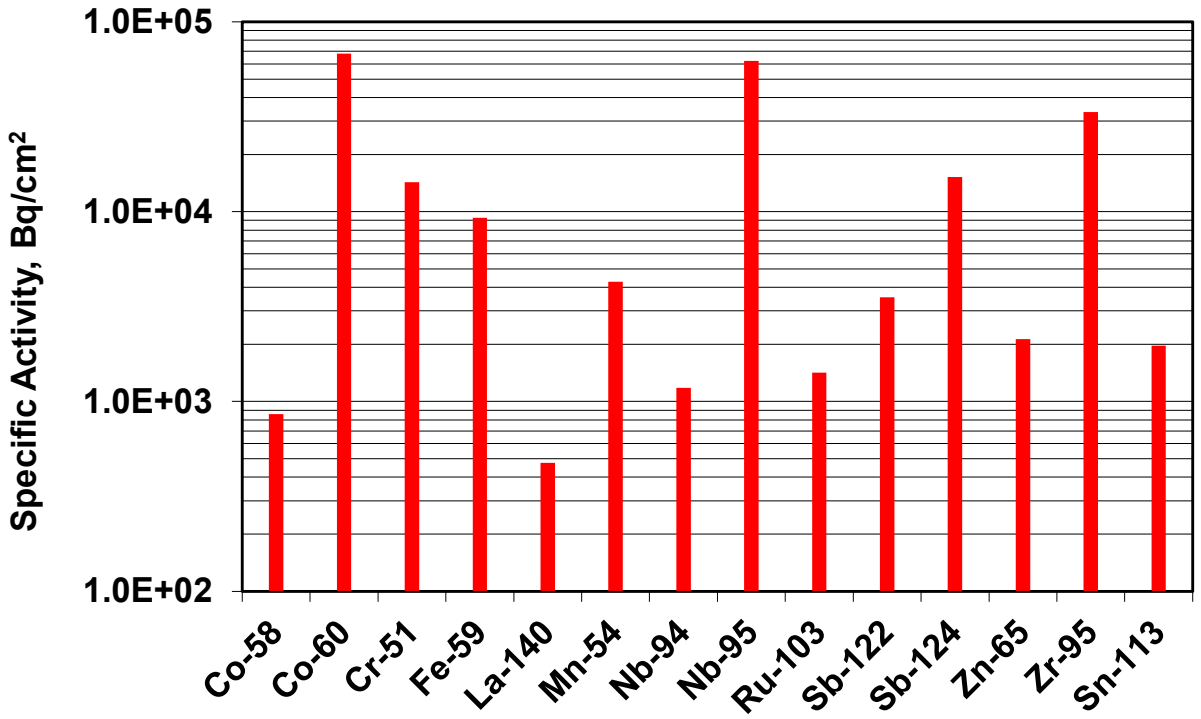
Activity Monitoring and Analysis

Assessments were based on the following:

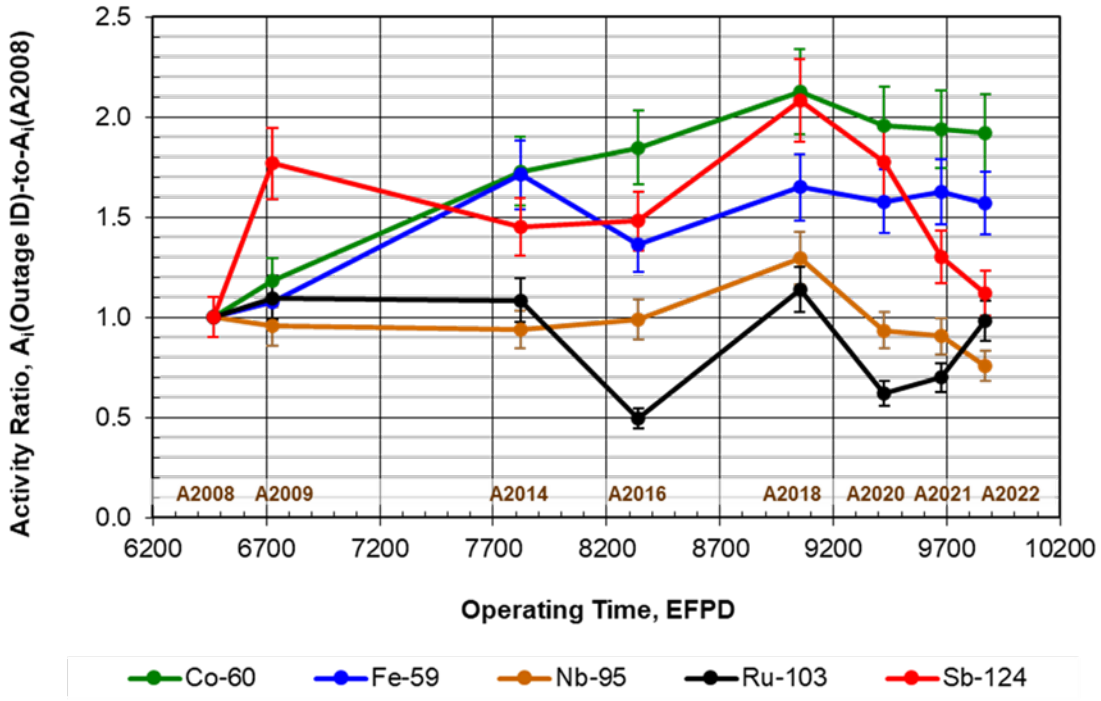
1. Gamma surveys in the vault:
   - after unit SD
   - before pH adjustment
   - after pH adjustment
2. Characterization of the Crud Samples
3. In-situ gamma spectroscopy of the spent PHT purification components (filters and IX resin)
4. Gamma activity monitoring in the vault during the PHT pumps start-up

Gamma Surveys during Unit Outage

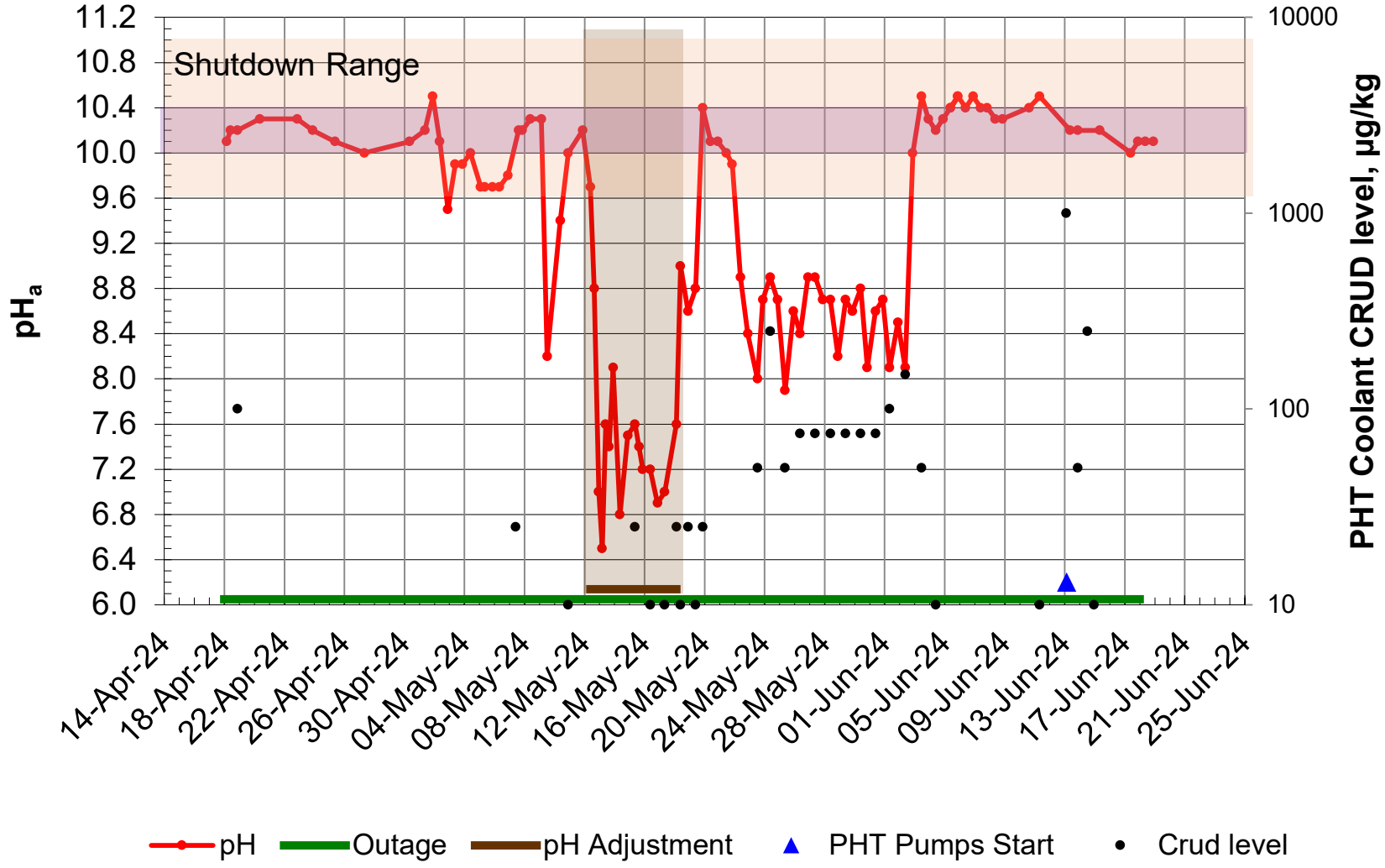
Typical Spectrum of Radionuclides



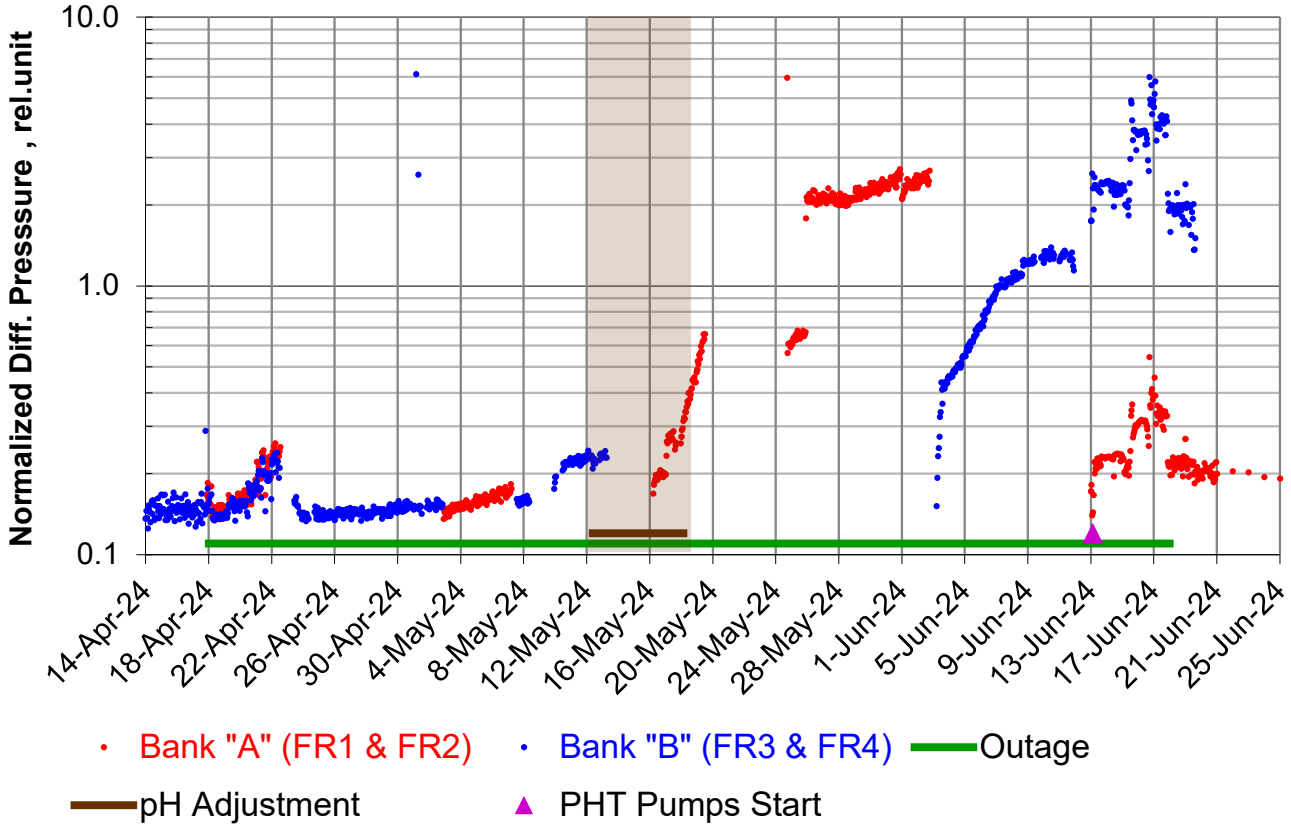
Gamma Activity Trends

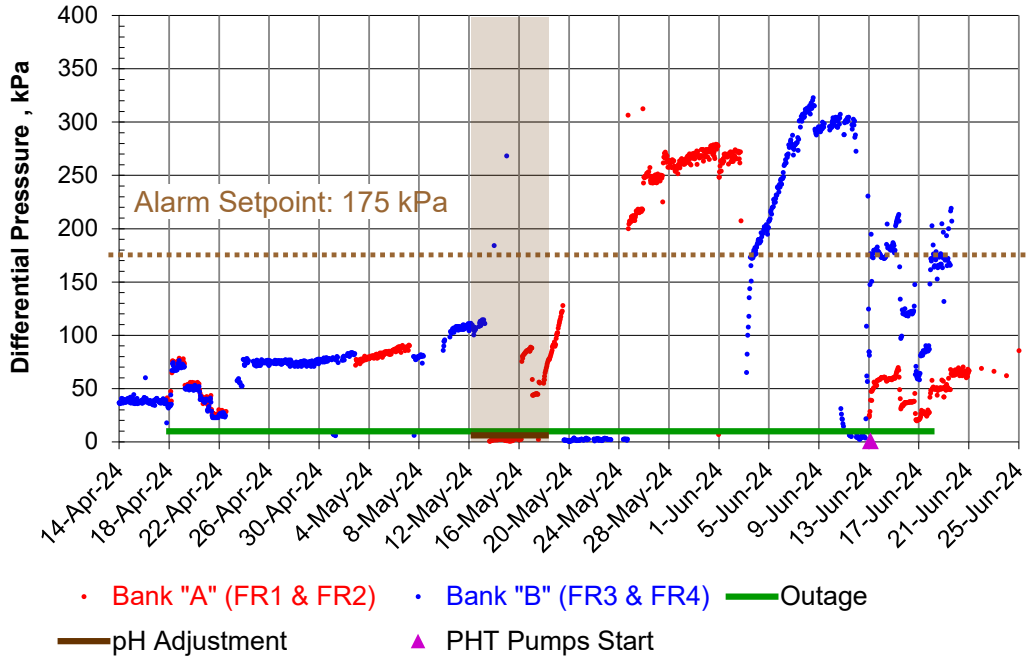


pH_a Excursions and Planned pH_a Adjustment

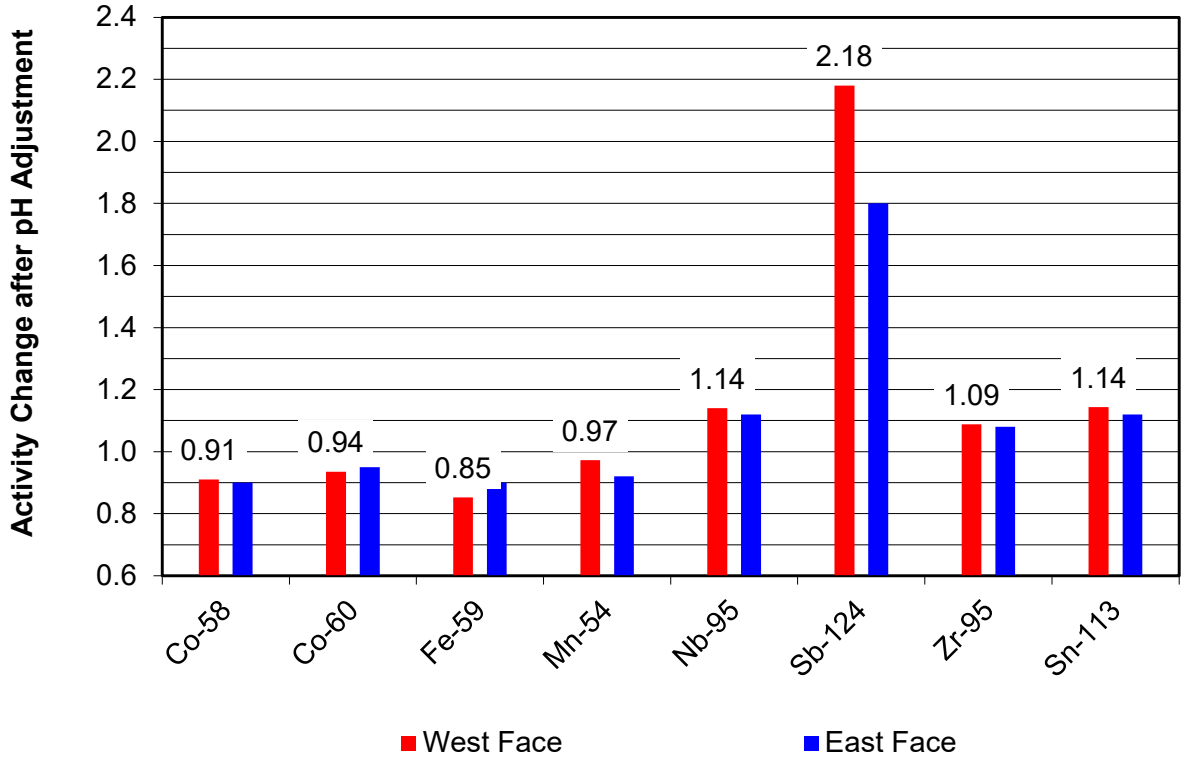


PHT Filters: Differential Pressure Trend



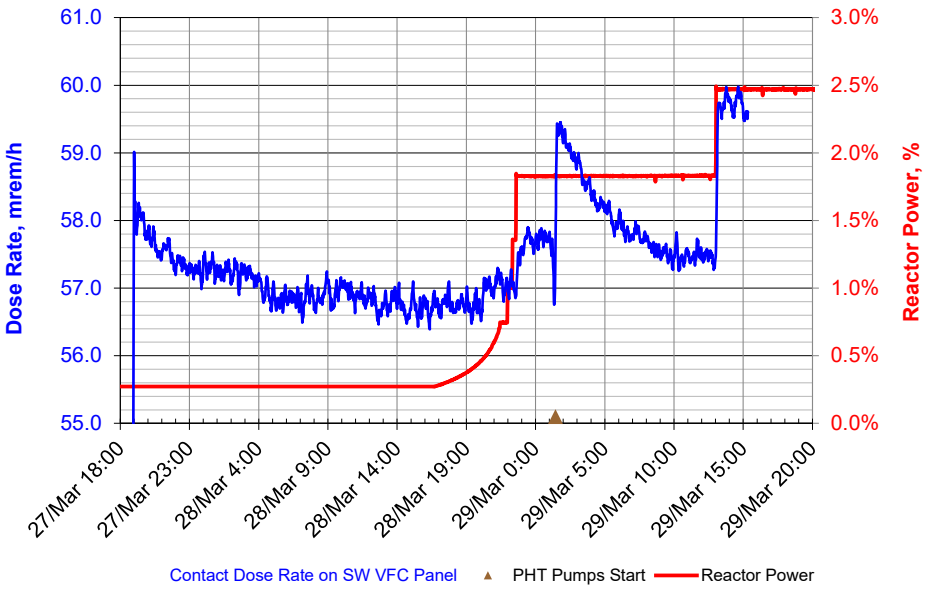


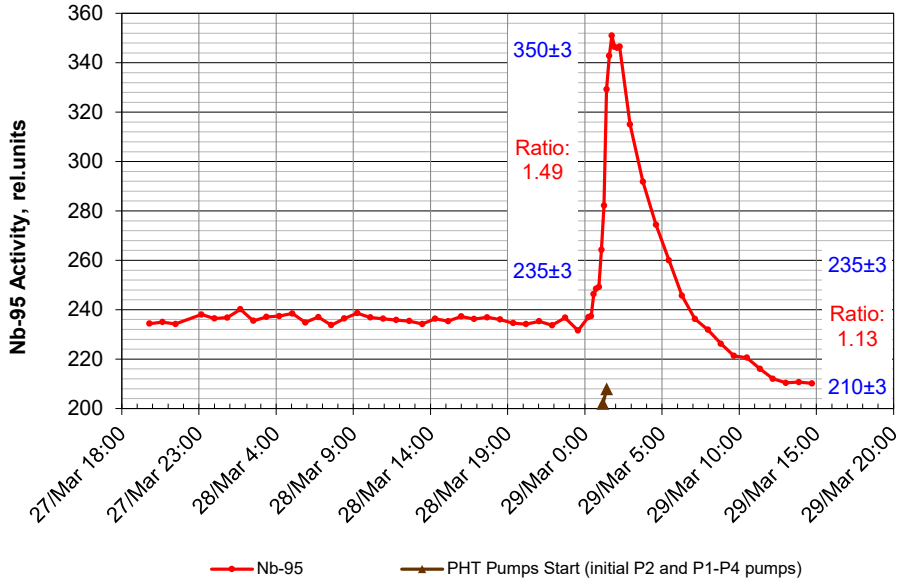
Case A: Monitoring before and after pH_a Adjustment

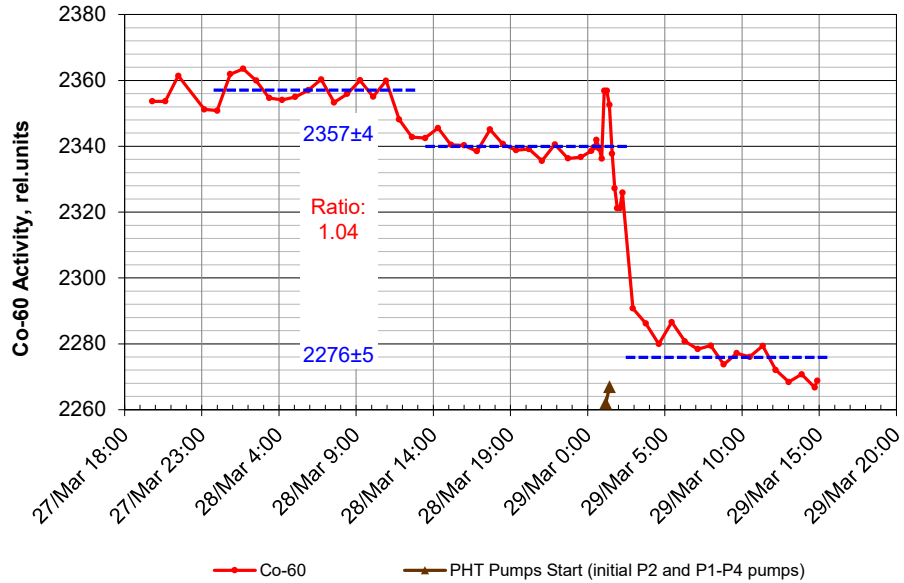


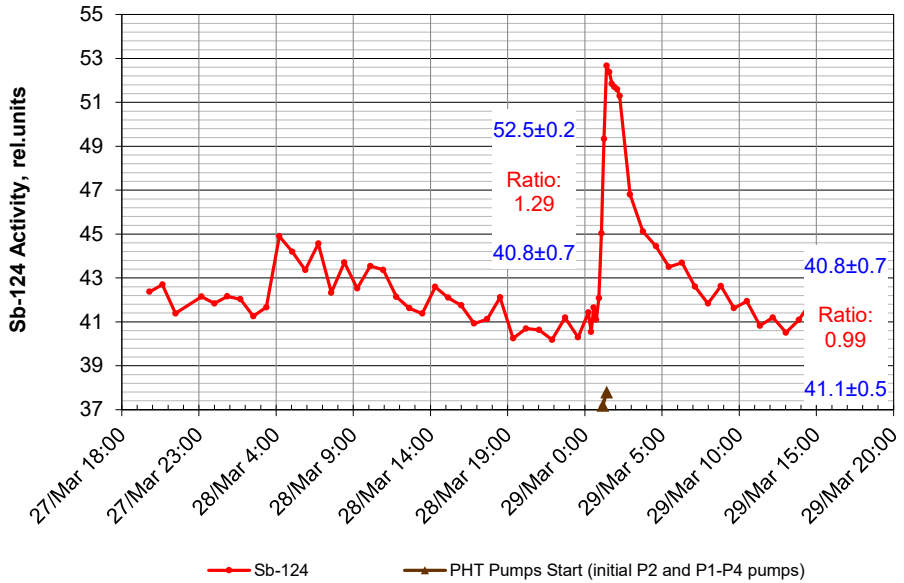
	West Face	East Face	Average Reduction for both Faces
Co-58	0.91	0.90	0.91
Co-60	0.94	0.95	0.94
Fe-59	0.85	0.90	0.88
Mn-54	0.97	0.92	0.95
Nb-95	1.14	1.12	1.13
Zr-95	1.09	1.08	1.08
Sn-113	1.14	1.12	1.13
Sb-124	2.18	1.80	1.99

Case B: Monitoring during the PHT Pumps Start-Up



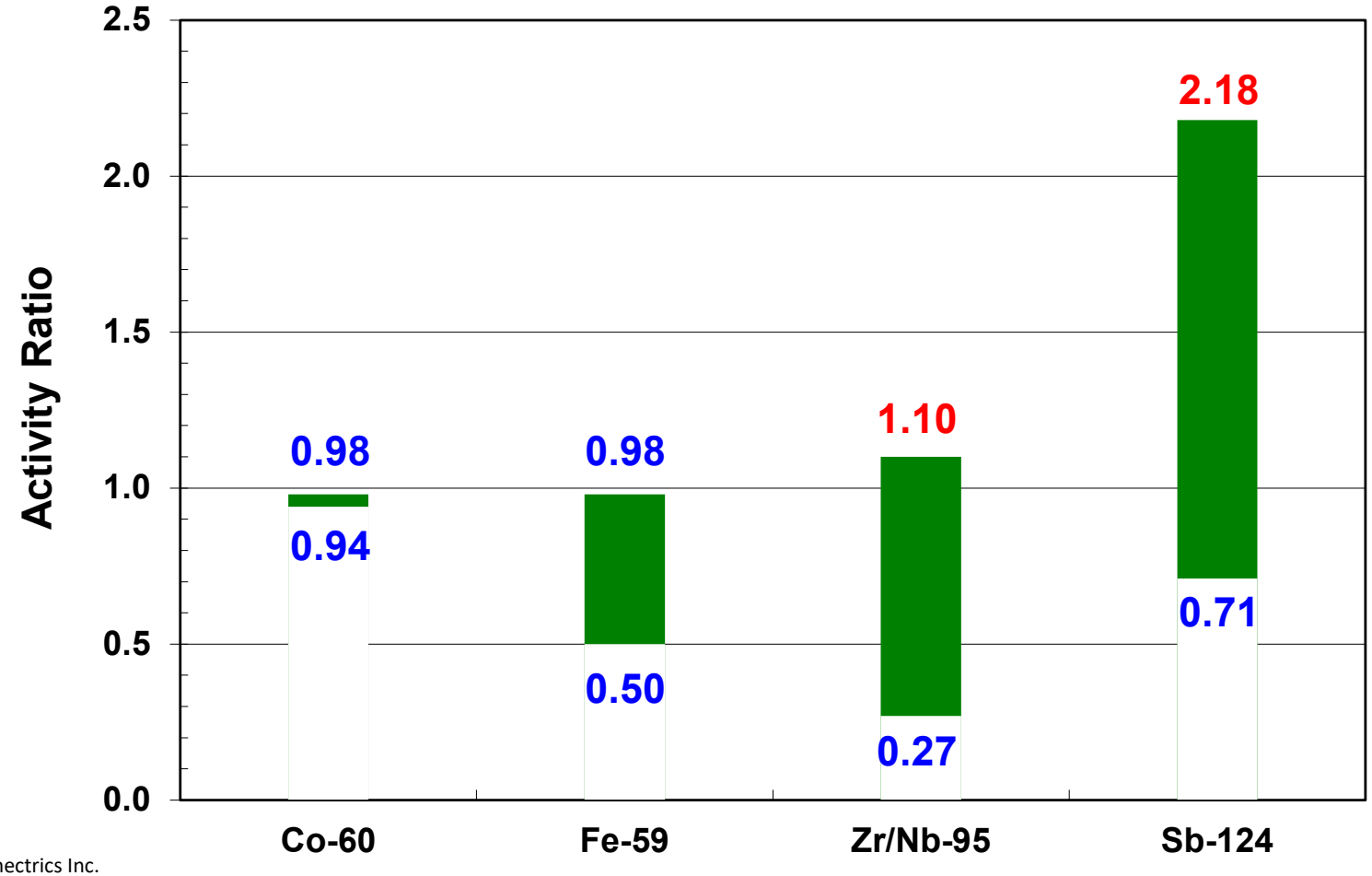






Concluding Remarks

Activity Ratio Before and After the Low pH_a Events



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