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Investigation of a cadmium contamination event during a radiotracer production activity

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Introduction

- On February 3, 2026, a 1 Ci Na-24 radiotracer was produced by irradiating 3.7 g of sodium carbonate in a reactor dry tube at the PSU Breazeale Reactor.
- This is not a novel technique, and is typically performed several times per year.
- When the shipping cask returned to the reactor, contamination was discovered on the accessible surfaces of the cask and on the cart where it was placed upon return. Later, contamination was also found on several tools used to transfer the sample.
- The contamination was determined to be Cd-115, an isotope that was not expected and was not on the shipping manifest.
- This presentation summarizes the event and follow-up, including the steps taken to identify the source of contamination and lessons learned.
- Document at PSU RSEC as operational event AP-4 #2026-01.

Reportable Event

- The shipping cask was returned to PSU by an independent courier contracted by the tracer customer. Their vehicle was a small van with a pet dog in the cargo area.
- The driver needed to brake quickly at the receiving site, which caused the cask to fall over. This is noteworthy as it may have affected the spread of the contamination.
- When the cask was received at RSEC, after the van had departed, ~20,000 CPM of contamination was discovered on a cart holding the cask and inside the cask flange when smeared with a swab.

Reportable Event

- The presence of contamination at or above 240 dpm / cm² on the outside of the cask was deemed to be a reportable event per 10CFR20.1906(d)(1).
- The event notification was made by the RSO within 24 hours of the receipt of the cask and discovery of contamination.
- The transport van was recalled to campus, and RSEC personnel along with the RSO performed a survey of the vehicle. No contamination was found in the vehicle.

Cask and Cart



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Swagelok Container



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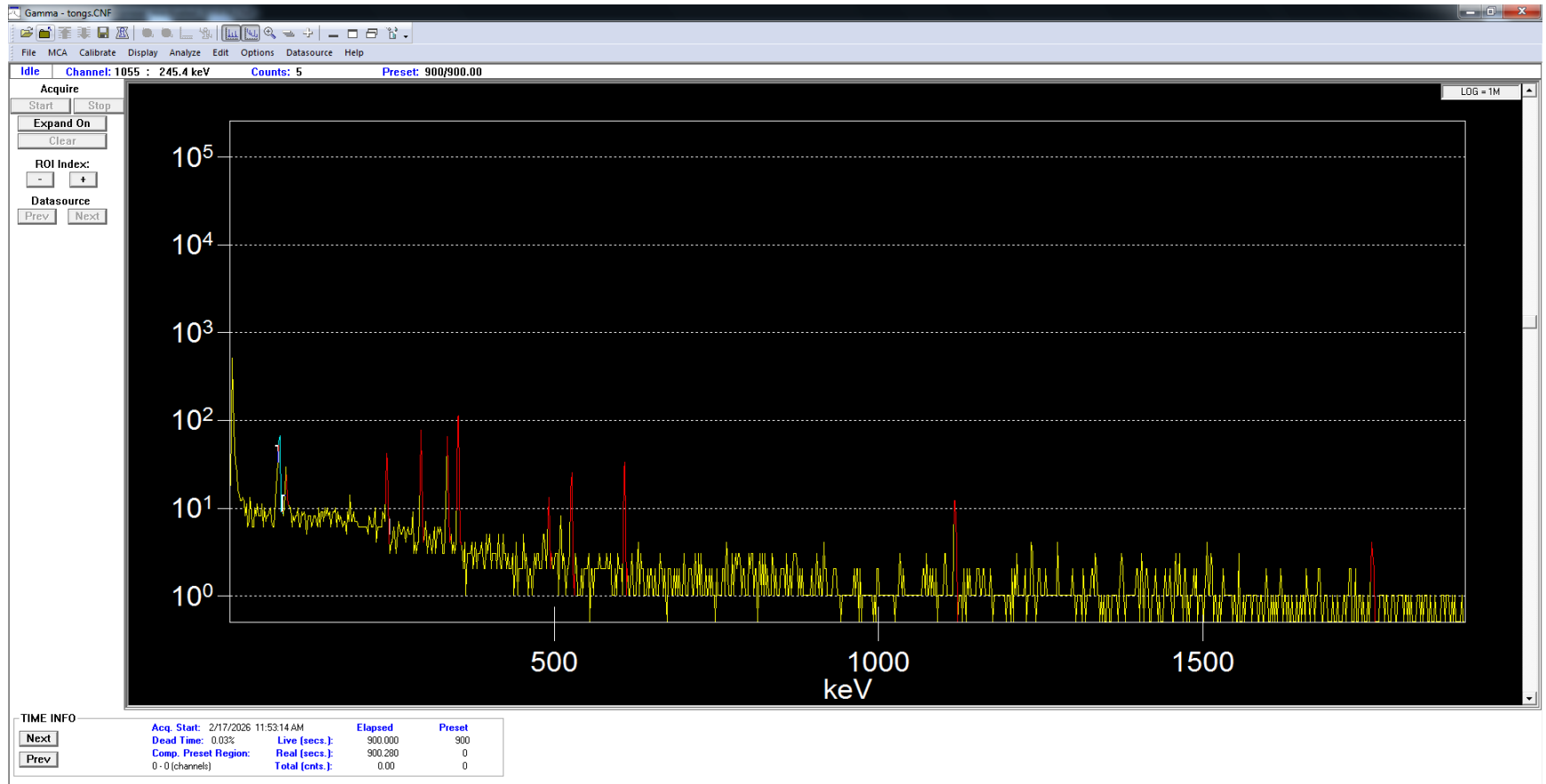
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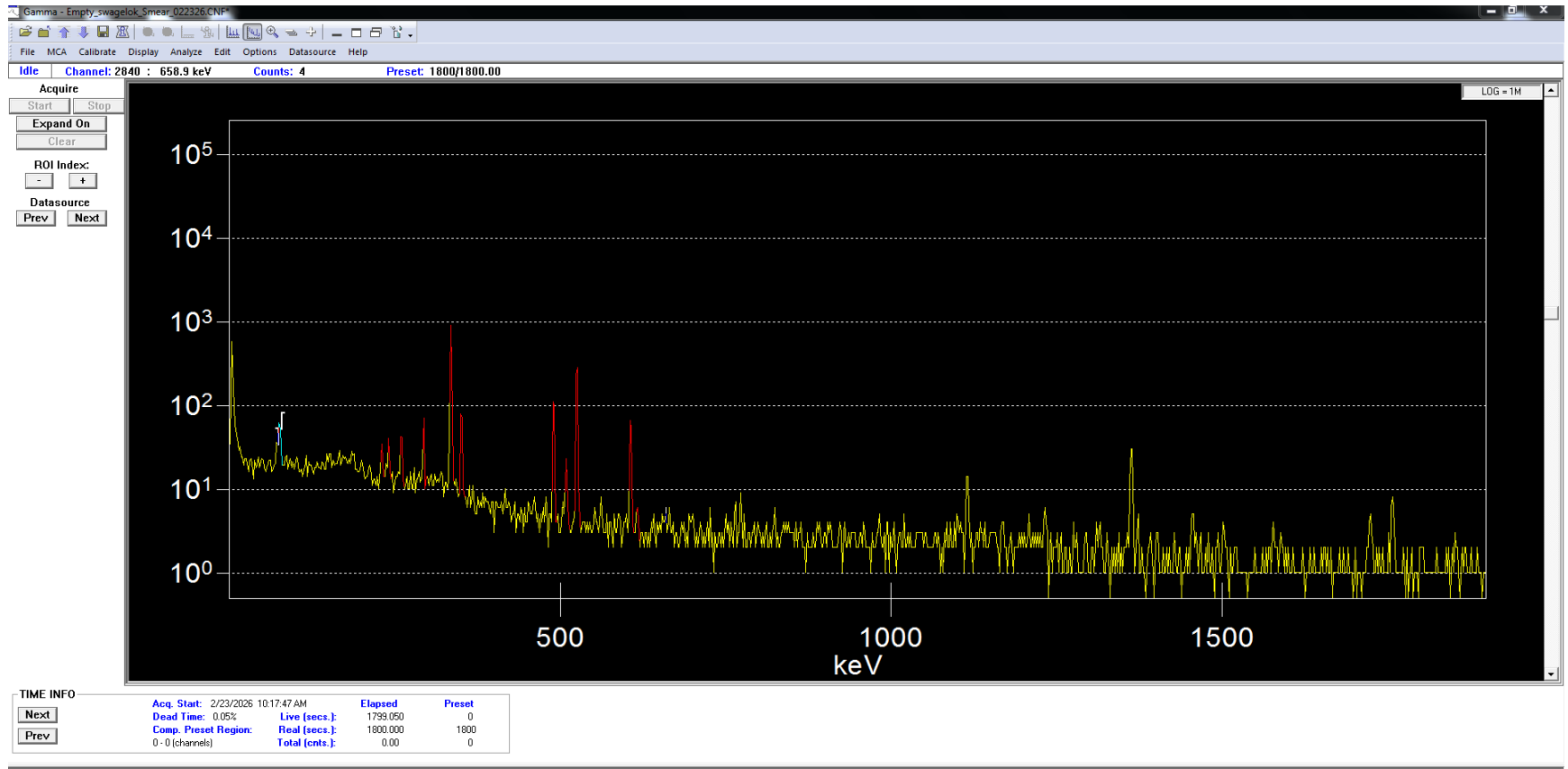
Cd-115

- Cadmium-115 is a beta- and gamma-emitting isotope with a half-life of 53.4 hours.
 - Easy to detect for about one week after contamination event.
 - Primary peaks: 336 keV (46%), 492 keV (10%), and 528 keV (27%)
- Cd-115 is produced through neutron capture in Cd-114, which has a thermal cross section of 0.34 b and resonance integral of 16.9 b.
- RSEC calculates expected dose rates and activities prior to irradiation. For the Swagelok, the composition and mass of each alloy in the technical drawings was used in the calculation.
- The list of elements included Al, Fe, Si, Zn, Ti, Mn, etc., but not cadmium.
- The irradiation procedure required 8 hours of irradiation at full power; approximately 1 mg of elemental Cd could have yielded contamination levels similar to what were observed.

Contamination Spectrum (Tongs)

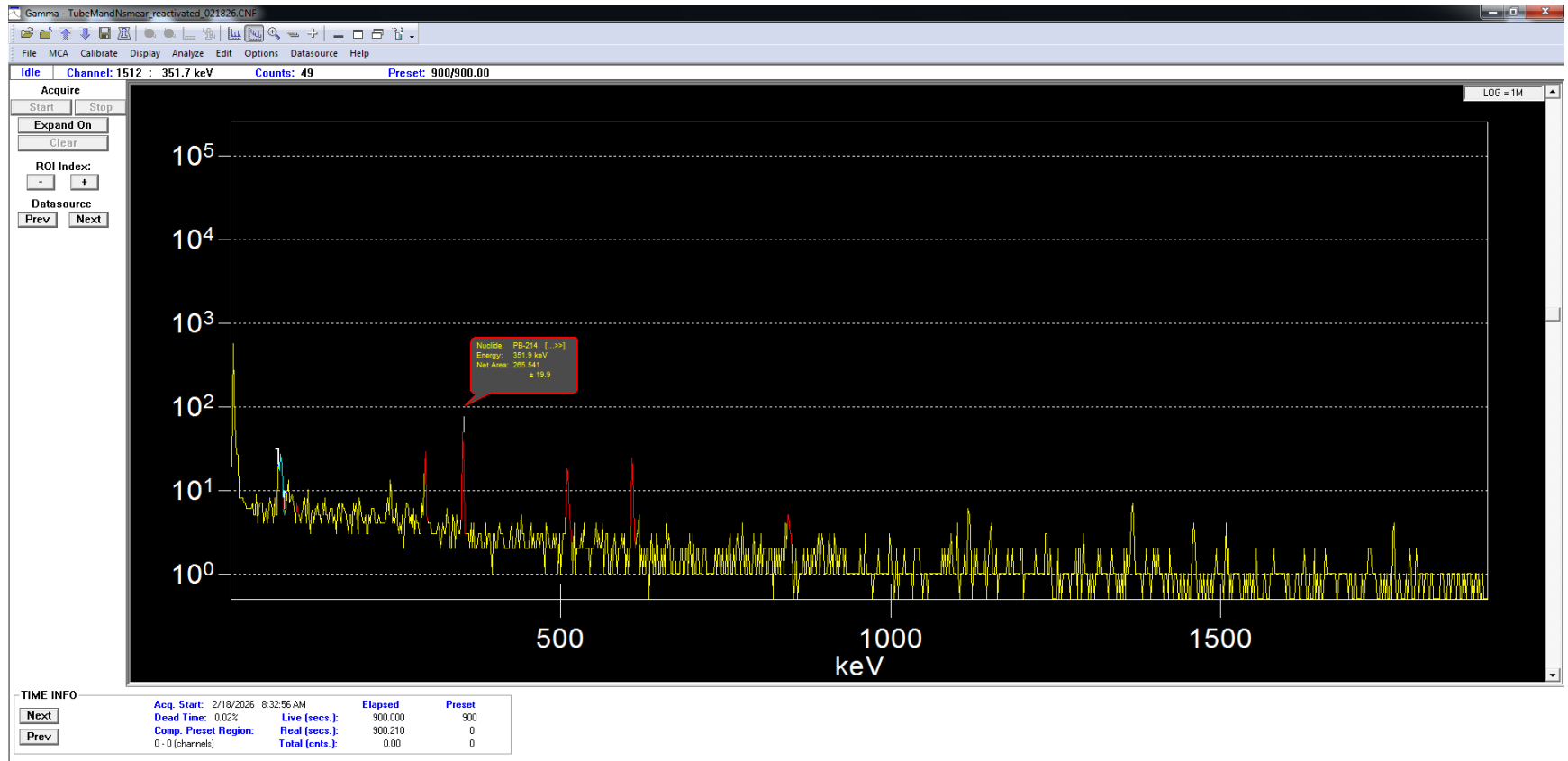


Contamination Spectrum (Empty Swagelok)



Contamination (Dry Tube)

The dry tube, when re-irradiated, showed background peaks but no Cd-115



Follow-Up

- Cd-115 was detected on some tools used to handle samples, including tongs and scissors.
- Various possible pathways for production were suspected:
 - Contamination and leaking of source powder (although no Na-24 was detected);
 - Cross-contamination from an earlier experiment with Cd-covered wires;
 - Cross-contamination from dry tube walls, i.e., cadmium from previous experiments eroding and then re-activating;
 - Cross-contamination with stable cadmium from shared tools used to prepare the sample.



Follow-Up

- A test run was performed in which two containers were irradiated, one with sodium carbonate powder and one without – both had Cd-115 when smeared.
- New dry tubes were fabricated, and a test run was performed with a vial sealed with new, unused tools – Cd-115 was still detected.
- Repeated smears of vials were performed after multiple rounds of cleaning – the contamination was present in similar quantities after each.
- Smears of various work surfaces and vial components were irradiated, and NAA was used to show cadmium in certain smears, especially those of the capsule.

Resolution

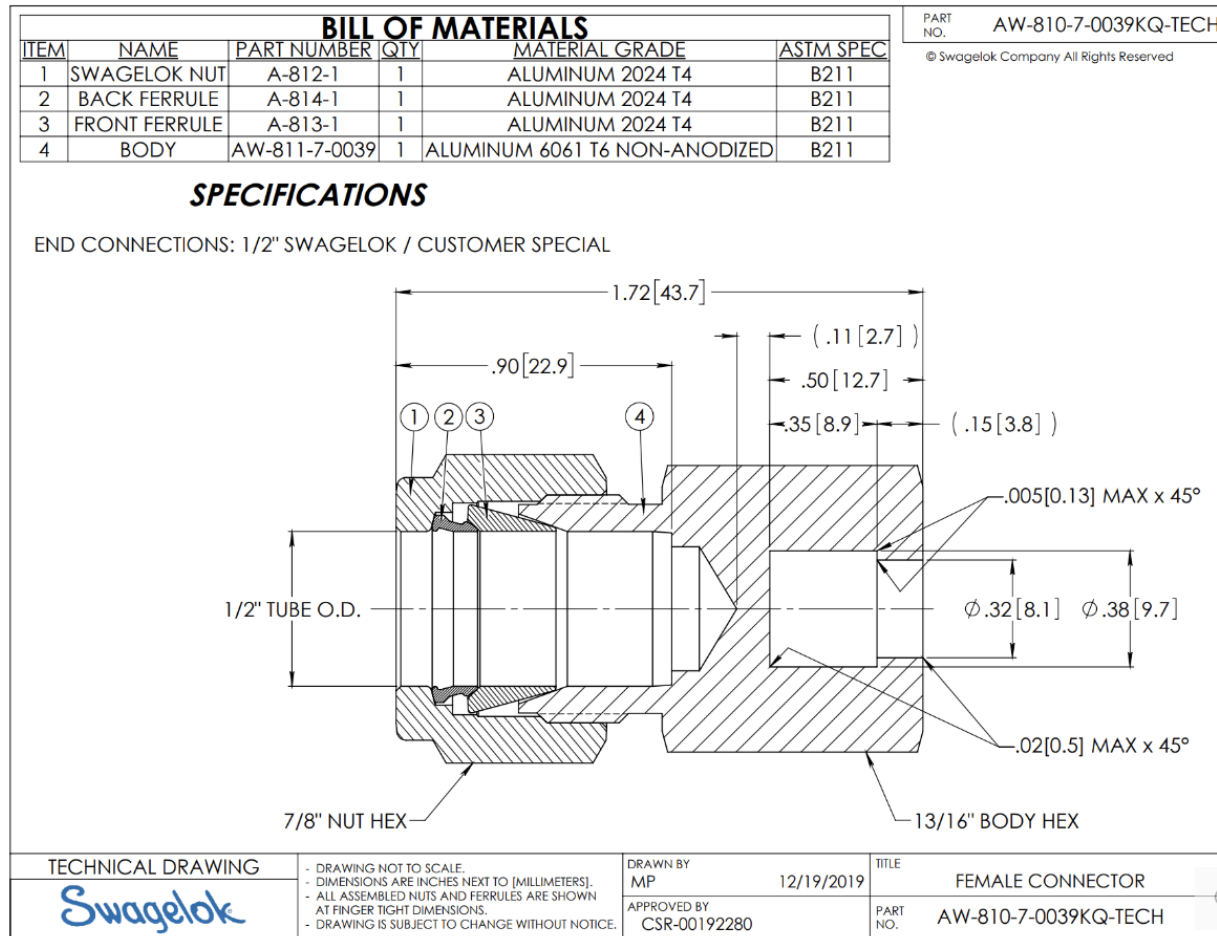
- Ultimately XRF was performed on the components of an unused Swagelok capsule.
 - Brendan Culleton, PSU Institute for Energy and the Environment Radiocarbon Lab
 - Bruker Tracer 5G Handheld
 - 40 kV, 13 μ A, Ti/Al filter
- Prominent Cd peaks were observed when testing the threaded nut.
- Alloy was specified on the drawing to be Al 2024-T4, which doesn't include Cd as a listed constituent.



Resolution

- Our tracer services customer contacted Swagelok.
- Swagelok replied that the nut was Al-2024 T4, but the threads were plated with cadmium to prevent galling during assembly.
 - Un-plated nuts are available by request (suffix code on part number)

Resolution



Contamination Control

- A complicating factor was poor contamination control.
- Several tools used to handle the samples were placed onto benches or into tool chests without checking for contamination.
- This was done on at least two occasions, including once after the reportable event, and had the potential to cause the unknowing spread of contamination.
- During the second event (April 10, 2026), low levels (500 – 700 CPM) of Cd-115 were found on the reactor low bay floor during a daily survey. During follow-up, up to 150,000 CPM was found on a work bench and contaminated tools were discovered in a tool chest, contaminating other tools and the chest drawers. Other contaminated tools were found in a tool chest in the prep lab used for Na-24 samples.



Contamination Control

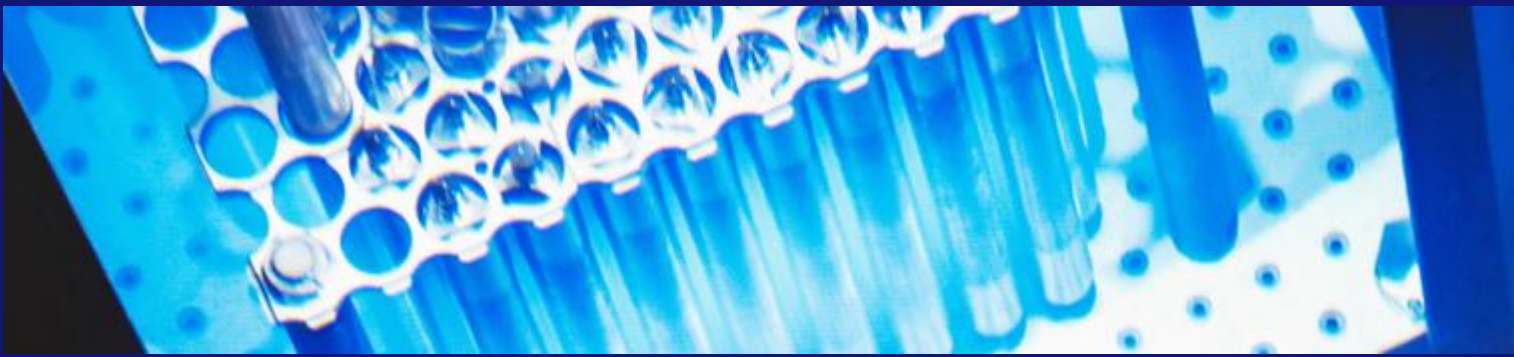
- These events, especially the 2nd event (AP-4 #2026-02), show that some senior reactor staff were not taking contamination control seriously, even after they knew of poor contamination control during the lead-up to the reportable event.
- RSEC will be introducing biennial practical radioactive material handling exams to avoid gradual loss of proficiency / diligence.

Conclusion / Moving Forward

- Confident that we have identified the source of Cd
 - No tracer irradiations have been performed since February.
 - Test irradiation will be performed with new batch of capsules before use.
- It is likely that Cd-115 was produced and shipped on other occasions, but we were not aware because the cask had never tipped over during shipment before.

Conclusion / Moving Forward

- Some improvements to work practices were made, and will be retained in spite of not being the direct cause of this event.
 - Dedicated tools to prevent cross-contamination
 - Improved communication with EHS when empty casks return to RSEC
 - Periodic requalification practical exam for safe handling of RAM
- Having an XRF system at the facility would be beneficial, and may be the target of a future DOE NEUP reactor infrastructure grant proposal.



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