



# Overview

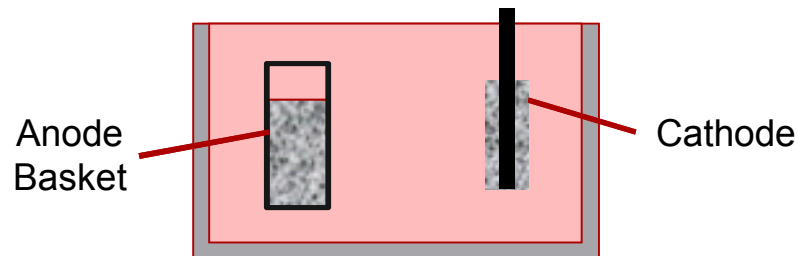
- Pyroprocessing presents several new challenges for materials accountability. The following will present the challenge areas and a preliminary safeguards approach.
- Outline:
  - Six key challenge areas
  - Preliminary safeguards approach
  - Gaps/unknowns

# Challenge 1: Flushouts

- Traditional aqueous plants rely on a plant flushout to perform the yearly physical inventory verification. Vessels are flushed out (with clean solutions) in order to complete the material balances.
- A commercial-scale pyroprocessing facility is designed to maintain a U and TRU content in the electrorefiner salt, and flushing out may not be practical.
  - One potential design alternative is to completely drawdown the actinide content from the ER salt periodically, which may be needed anyway for fission product removal.
- This could change the safeguards regime to reliance on interim inventory verifications only.

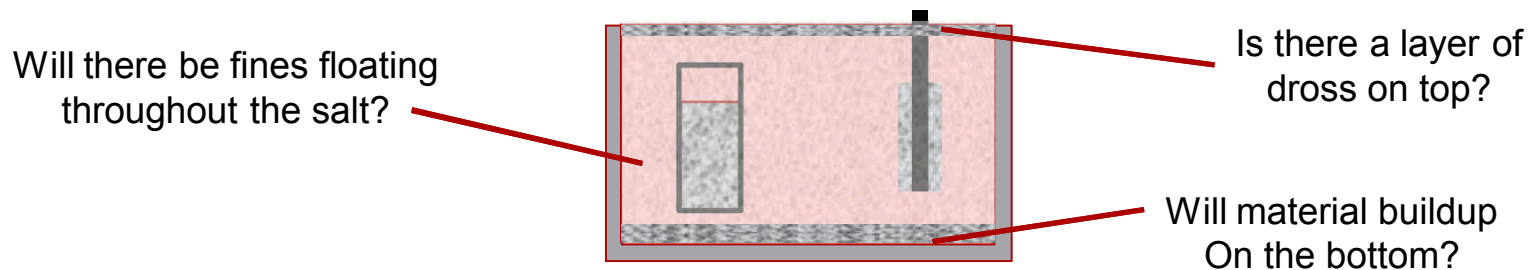
# Challenge 2: Input Accountability

- Since pyroprocessing does not include a dissolution step, the spent fuel must be measured at some point before being processed (and measurements of spent fuel typically have high uncertainty).
- Various options being pursued include mixing and sampling shredded or voloxidized fuel for DA or NDA. Measurement uncertainty may be limited to 2-3%.
- An alternative might modify the materials used for U and U/TRU extraction in order to quantify the amount of Pu going in and out of the salt.



# Challenge 3: ER Salt Inventory

- The ER salt will contain large quantities of actinides, so measurement of the salt is a priority.
- Salt sampling and DA will likely be used, but it is unclear whether the samples will be representative.
  - Metal fragments and other in-homogeneities (dross) could be a problem for holdup.
- May need to consider filtering of the salt periodically in order to quantify both the salt and holdup better.

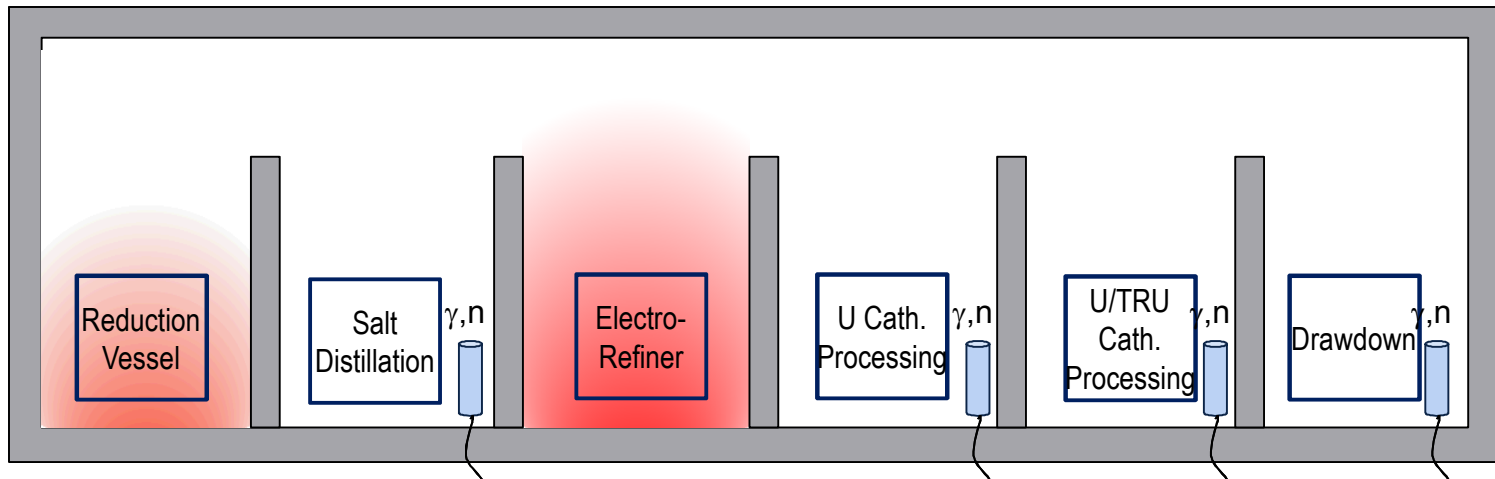


# Challenge 4: Product Accountability

- The U and U/TRU ingots are the two products from the process and so must be measured well. A 100 MT/yr facility may produce one U ingot per day and a U/TRU product once every ten days.
- NDA measurements would be preferable, but uncertainty might be limited. An alternative is melt sampling and DA, but difficult to turn around a sample every day.
- Process Monitoring might play a role here to help provide assurance.

# Challenge 5: Confirmatory Measurements

- Many of the processing vessels can be designed to be empty at the time of an inventory measurement, but confirmatory measurements are needed.
- Confirmatory measurements in a hot cell environment can be difficult due to the radiation field.
- The hot cell may need to be designed with shielding in between unit operations to facilitate (Safeguards by Design).



# Challenge 6: Process Monitoring

- Pyroprocessing presents new data types that can be monitored to ensure normal operations and detect facility misuse (current, voltage, off-gas, etc.).
- Research is needed on how best to use that information (pattern recognition, confidence?).
- In addition some of this information may be required to fill in the gaps in materials accountability.



# Gaps & Unknowns

- The safeguards design will depend strongly on achieved measurement uncertainties.
- Poor performance of input accountancy may require a change in the mode of operation.
- Difficulties in measuring the ingots may require more reliance on process monitoring (current/voltage monitoring).
- Process monitoring is being examined to reduce dependency on sampling.
- NDA measurements in the hot cell should be examined.

# Summary

- The challenges that exist for pyroprocessing will require new approaches for safeguards.
- A number of options are being considered including various measurement technologies, more reliance on process monitoring, and design changes to increase the effectiveness of safeguards measurements.
- Safeguards by Design will likely be more important for pyroprocessing than has been implemented in the past, but fortunately these concerns are being addressed well before any future plants would be built.