U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

Calcine Retrieval Project Update

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Context: HLW Calcine

- What is the Waste: High Level Waste Calcine from the reprocessing of spent nuclear fuel at INTEC.
- Potential Risks: Waste contains long lived radioactive isotopes which pose a risk to workers and the environment. Retrieval and treatment of the calcine and shipment for disposal in a deep geologic repository ensures that humans and the environment are protected from the waste for the thousands of years that it remains harmful.
- Settlement Agreement: Requires that calcine be made “road ready” to ship out of Idaho by 2035.
- How treated/disposed: Plans are to retrieve calcine from storage, treat it to meet the disposal facility waste acceptance criteria, and ship it to the disposal facility once it is available.

- Current Budget: Only FY 2017 work (approx. $4.5M) is funded and part of the ICP Core Contract.

Calcine Retrieval Project (CRP)

- Demonstrate ability to retrieve and transfer calcine from Calcine Solids Storage Facility (CSSF) 1 to CSSF 6.
- Demonstrate ability to remove residual calcine to the "maximum extent practical."
- Close CSSF 1 to meet multiple requirements and establish an approach that will be applied to remaining 6 bin sets.
- The project is projected to complete CSSF 1 closure by FY 2022.
- Estimated cost is approximately $50M.

CRP Preliminary Schedule

- ✓ FY 2016 - Prepare conceptual design and regulatory strategy
- ◆ FY 2017 – Test retrieval and transfer concepts *(in progress)*
- FY 2018 – Prepare CSSF 1 for calcine removal
- FY 2019 – Construct retrieval and transport system
- FY 2020 – Transfer calcine from CSSF 1 to CSSF 6
- FY 2021 – Remove retrieval and transport system
- FY 2022 – CSSF 1 final closure

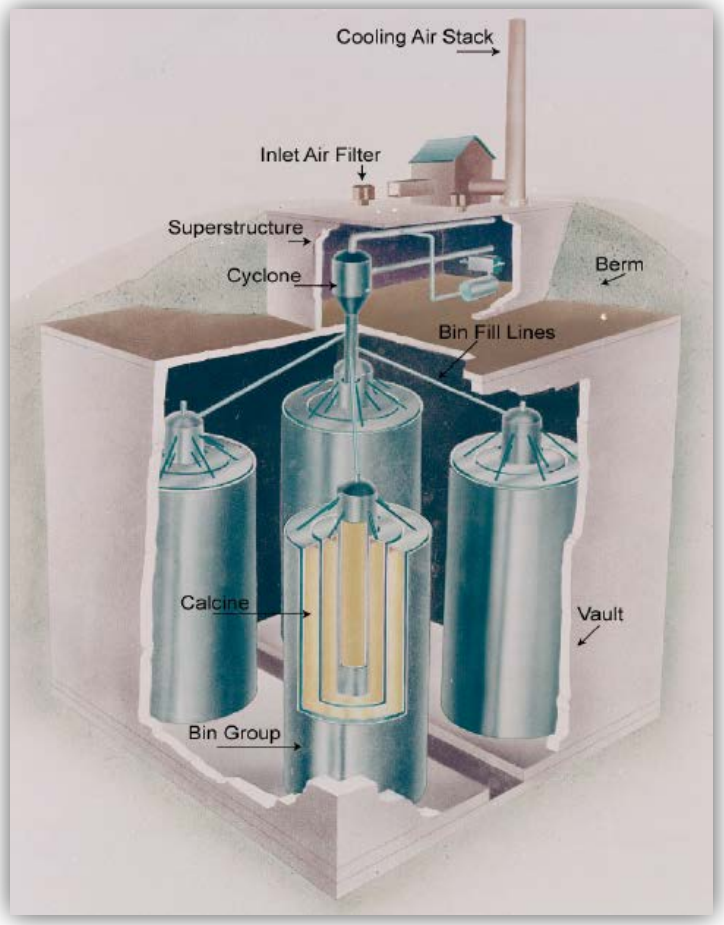
Note – Only FY 2017 work is currently funded and part of the ICP Core Contract. All other dates and scope are tentative and undefinitized.

Calcine Retrieval and Transfer

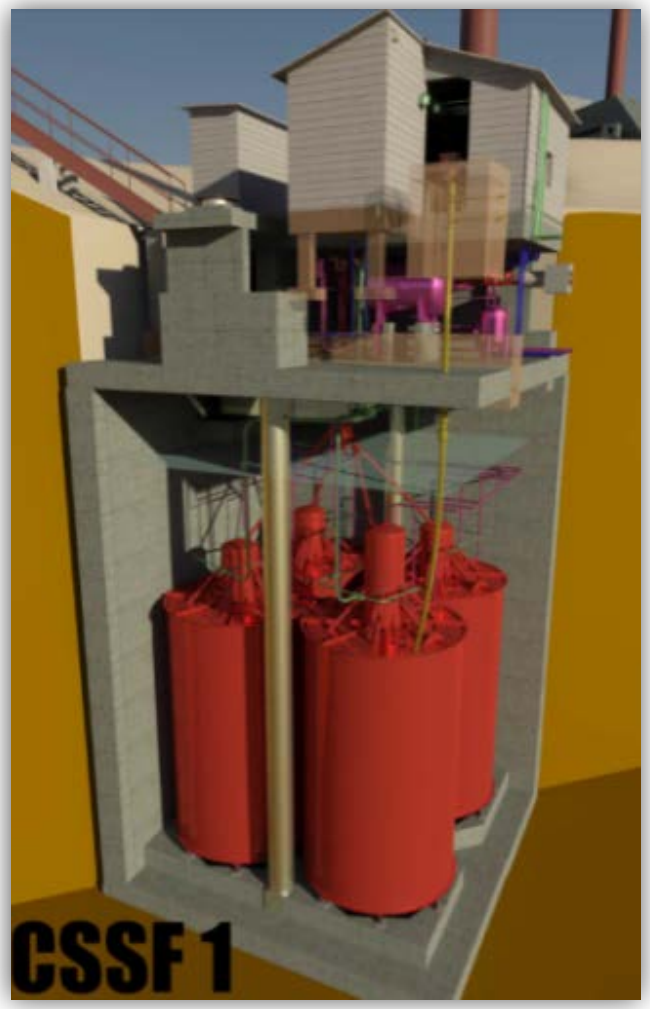
- Requires modifications to CSSF 1 and CSSF 6 to perform retrieval and transfer operations

- Unique CSSF 1 challenges
  - Not designed for retrieval
  - No bin access pipe risers
  - Internal vault and bin obstructions
  - Unknown calcine flow characteristics
  - Extent of calcine retrieval unknown

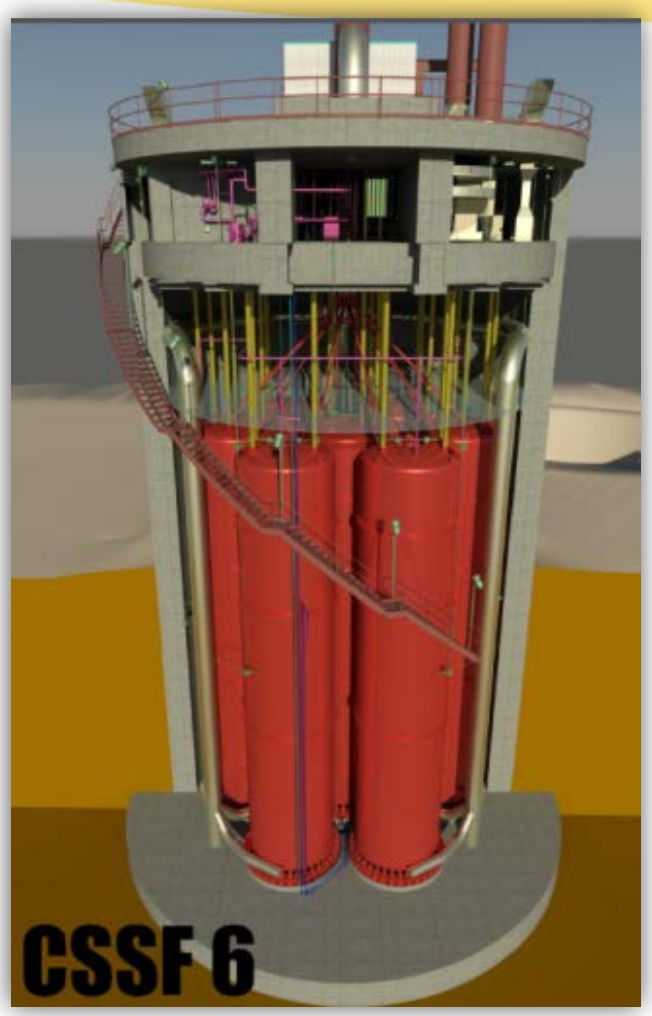
- Proof-of-concept testing necessary



CSSF 1 and CSSF 6 Computer Model



Contains 220 cubic meters of calcine



Contains 713 cubic meters out of total capacity of 1506 cubic meters

Retrieval and Transfer Concept Testing

- CSSF-1 retrieval testing
  - ✓ Thermowell conversion *(successful)*
  - ✓ Distributor/fill line clean-out *(successful)*
  - Core drill and capture
  - Remote bin surface weld preparations and access riser welding
  - Retrieval vacuum pipe installation
  - Bottom-up retrieval validation
  - Top-down residual clean-out system
- Integrated mockup testing
  - Construct full-scale prototype retrieval and transfer system
  - Construction complete December 2017

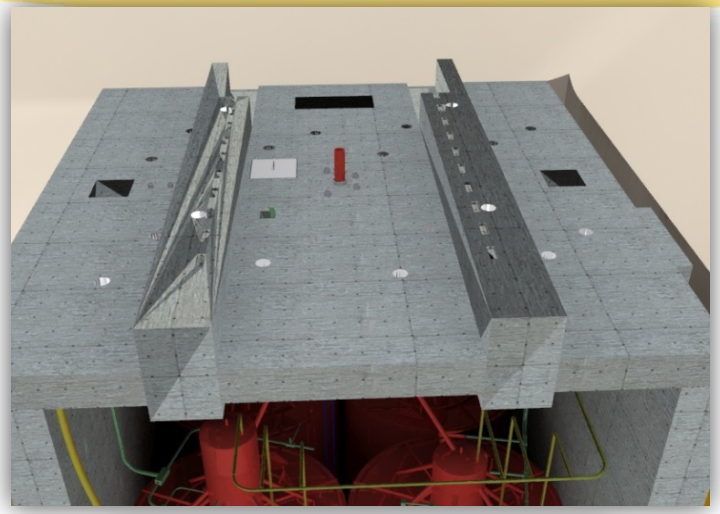
Distributor Clean-out Testing

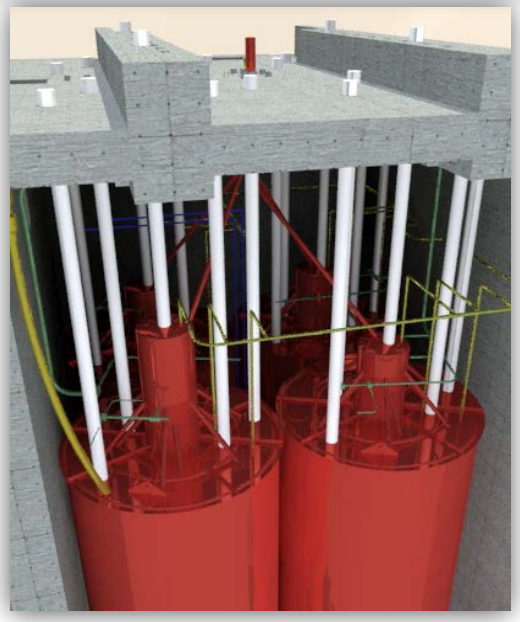
- Bins filled sequentially from a distribution piping system
- Distributor/fill lines are partially filled with calcine
- Task
  - Fabricated scaled replica of distributor and fill lines
- Test objectives
  - Tested flexible vacuum retrieval and fluidizing air jet system
  - Evaluated effectiveness of three different air jet systems
  - Determined viability and need for continued development
- Test results
  - Distributor and fill line clean out successful

Distributor Mock-up

Core Drilling Demonstration

- Vault roof 21 inches thick
- Vault roof and bin integrity must be maintained
- Task
  - Fabricate a vault roof replica that will be supported above ground for core drilling viewing
- Test objectives
  - Demonstrate ability to core concrete vault roof
  - Demonstrate capability to safely capture core
- Start test June 2017

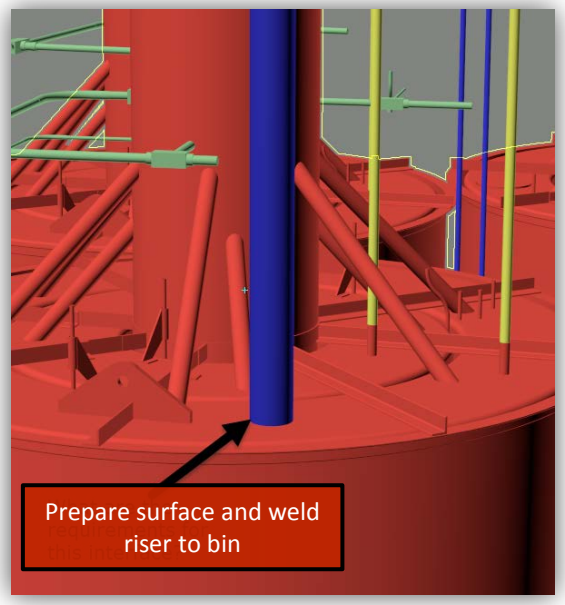


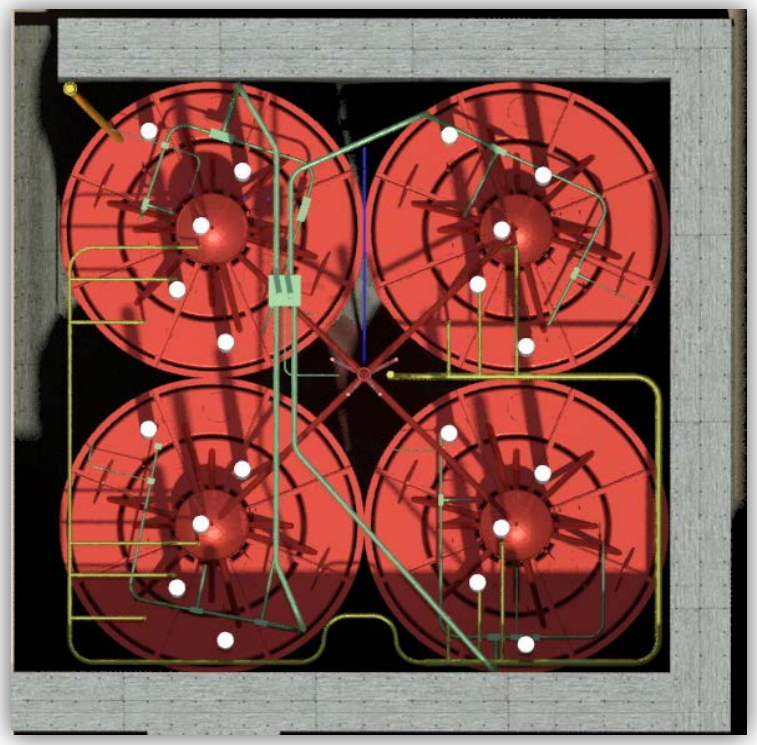


Bin Surface Preparation and Access Riser Installation

- Develop an approach for attaching risers to bin group
- Demonstrate remote surface preparation
- Demonstrate remote access riser welding

Remote pipe welder

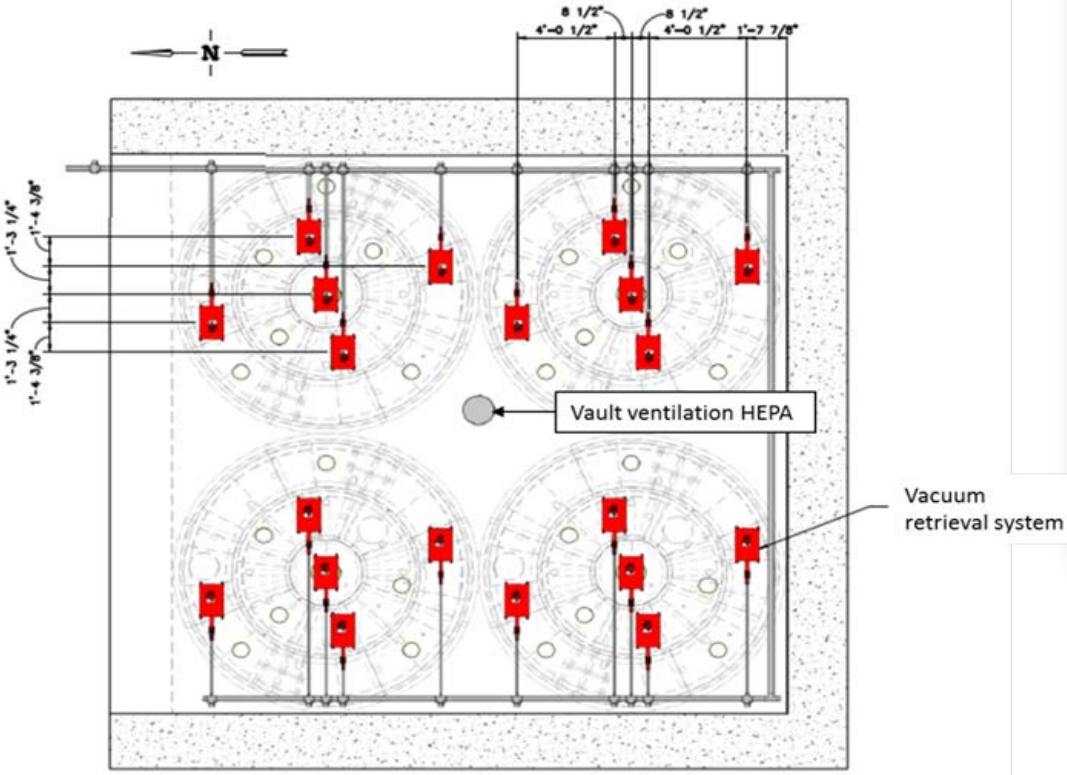




Retrieval Vacuum Pipe Installation

- Develop a method to place a vacuum retrieval pipe through the calcine to the bottom of the bin

- Place retrieval pipe through risers into each bin



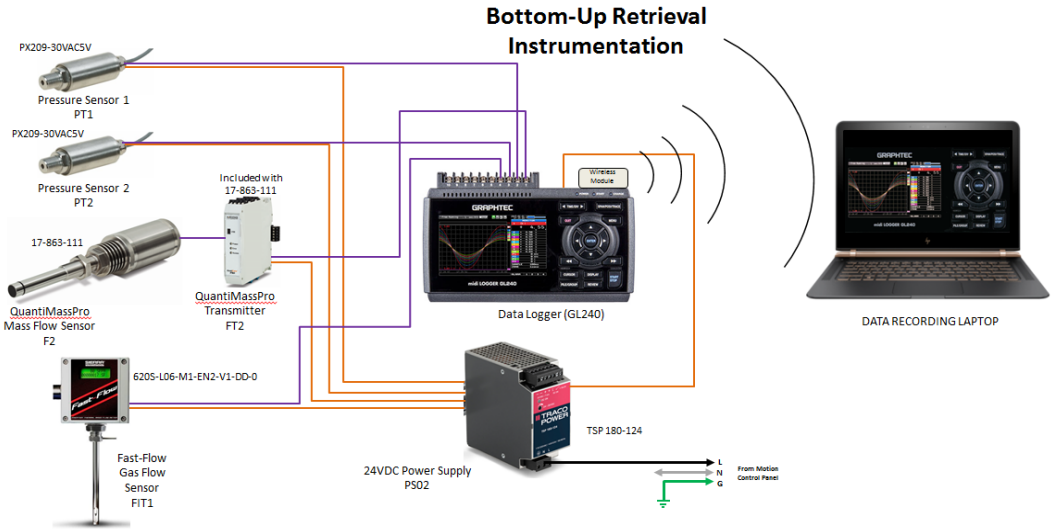
Bulk Retrieval Locations

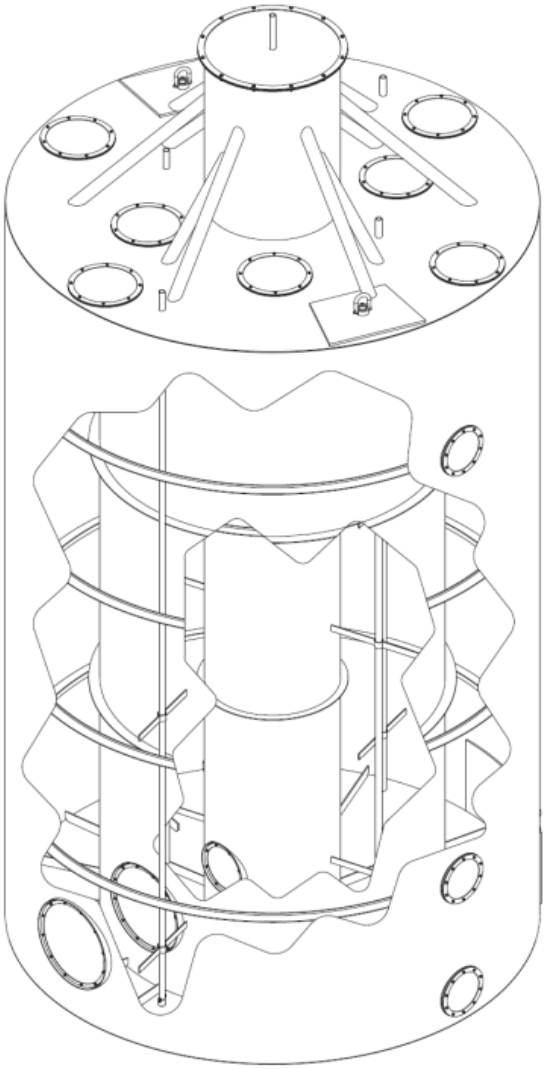
Pneumatic Pipe Driver

Retrieval Testing

- Tasks
  - Construct full-scale mockup of bin group *(in progress)*
  - Equip with bottom-up and top-down retrieval equipment

- Test Objectives
  - Demonstrate viability and capability of retrieval technology
  - Determine how much material can be removed
    - Bottom-up bulk retrieval (~85%)
    - Top-down residual retrieval (~15%)

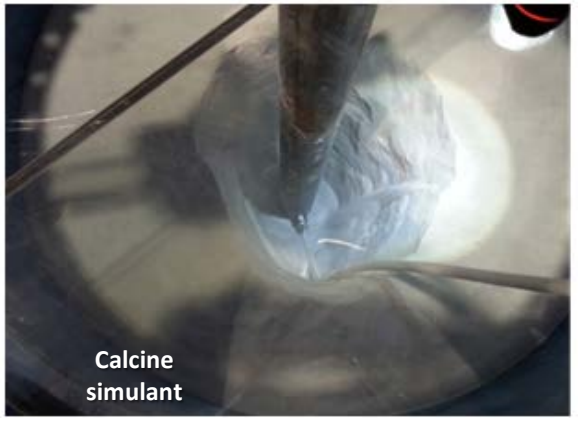


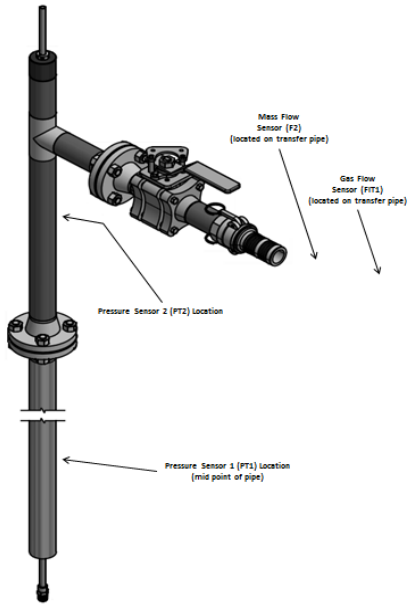


Mockup Bin Group

Bottom-up Retrieval Validation

- ✓ Proof-of-principle retrieval test (FY 2015)
  - Rates in excess of 1,000 lbs/hr achieved
- Test full scale vacuum retrieval apparatus
- Define operating parameters
- Evaluate retrieval rate, flow characteristics, and bin cleanliness





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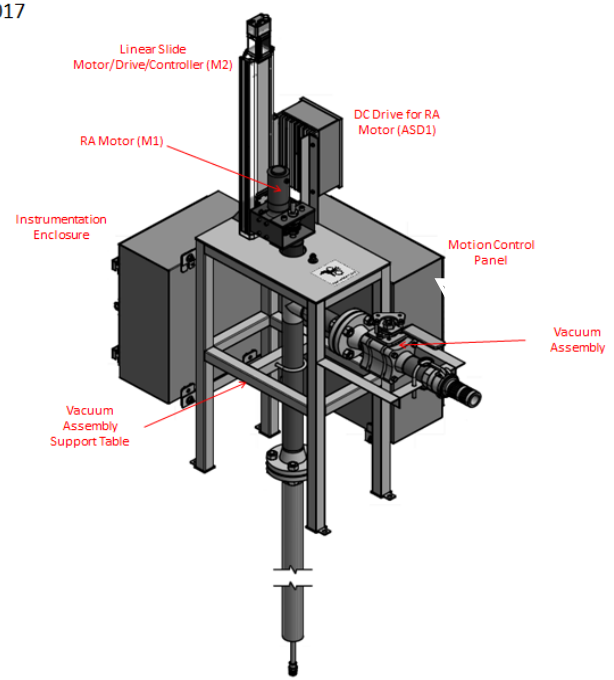

Top-Down Residual Cleanout

- Develop supporting equipment to cleanout residual calcine to the "maximum extent practical"
- Two design paths to evaluate and develop different residual retrieval methods
  - Track A – Simple articulating arm
  - Track B – OC Robotics snake-arm technology
- Contract awarded to OC Robotics
  - ✓ Kick-off meeting (May 2017)
  - Computer simulation development (June 2017)
  - Full-scale demonstration in Idaho Falls (July 2017)

Full-scale Retrieval and Transport Prototype

- Integrated retrieval and transport system that replicates final design parameters
- Retrieval System
  - Full size bin with internal and external obstructions
  - Automated bulk retrieval system
  - Residual calcine removal system
- Transport system
  - Transport line replicates diameter, velocity and pressure drop
  - Incorporates blind-tees
  - Incorporates sensors and controls
- Separation/filtration
  - Cyclone separator, prefilter and HEPA filter
  - Transport system blower

Full-scale Prototype Objectives

- Retrieval
  - Determine how to control retrieval rates and what rates are possible
  - Identify startup and shutdown sequence
  - Determine method for verifying bulk retrieval is successful
  - Develop method to identify if bulk retrieval stops and how to recover
- Transport
  - Develop steps to recover from upset conditions
  - Determine transport line flow and pressure drop characteristics
  - Define optimum control system design
  - Identify erosion at transitions and on equipment
  - Determine the types and locations of sensors
- Separation/filtration
  - Determine how much material gets past the cyclone
  - Determine how much material loads on filters
  - Determine optimum filter operation