Sandia National Laboratories

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Design, Construction Progress, and Cold Commissioning of the Gen 3 Particle Pilot Plant (G3P3)

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Outline

- Timeline
- Receiver
- Storage
- Primary Heat Exchanger
- sCO2 Loop
- Balance of Plant
- Installation

System Overview

Parameter	G3P3-USA
Receiver thermal power	~2 MW_t
Solar multiple	~2
Particles	CARBO HSP 40/70 ceramic beads
Receiver	Falling particles with SNOUT and StAIR; single slide gate
Heat exchanger	1 MW_t duty; Moving packed bed; particle flow in shell; 20-25 MPa sCO2 flow in plates
Particle Lift	Bucket elevator
Power block	~1 MW_t sCO2 flow loop
Tower structure	Open

Tower

G3P3-USA Construction Timeline

- **March 2021** – Phase 3 awarded
- **May 2022** – Re-issued NEPA complete/Re-baselined schedule
- **September 2022** – Tower construction began
  - **January 2023** – Broke ground
  - **February 2024** – Steel top out
  - **June 2024** – Bridge crane/elevators installed
  - Expected tower completion is **October 2024**
- **June 2024** – CARBO particles delivered
- **July 2024** – CSP equipment lift
  - PHX from VPE has been delayed until late **August 2024**
- **July 2024** – Plan B PHX executed
- **December 2024** – Completion of particle loop assembly
- **January 2025** – Commissioning of the G3P3 System

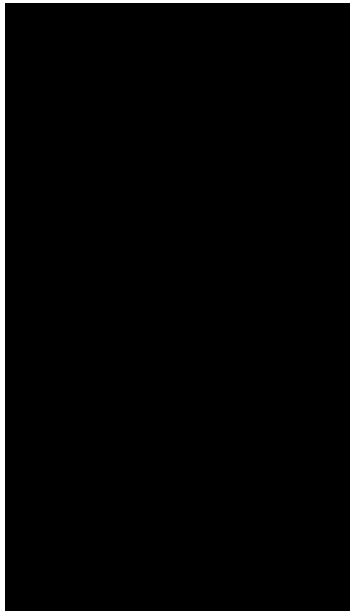
Near complete G3P3 tower with the existing NSTTF Tower

Tower Construction

- The G3P3 tower is in the final stages of construction

Poured and cured drilled piers and pier caps

Installing “cold” storage bin



Completed first structural steel splice

Tower top out

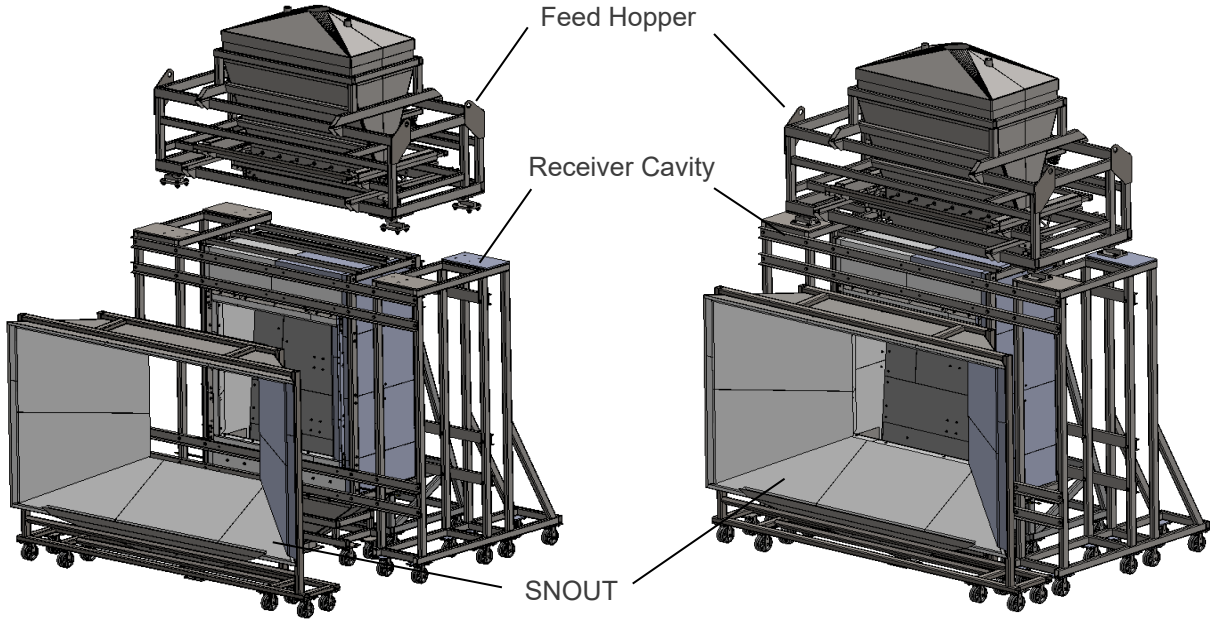
Completed installation of hot storage bin

Early installation of CSP components (July 2024)

Receiver

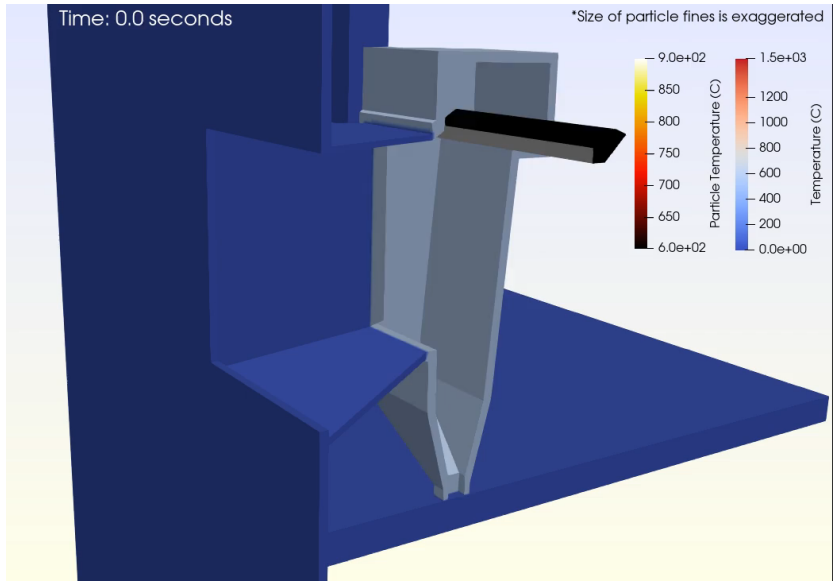
Receiver Design

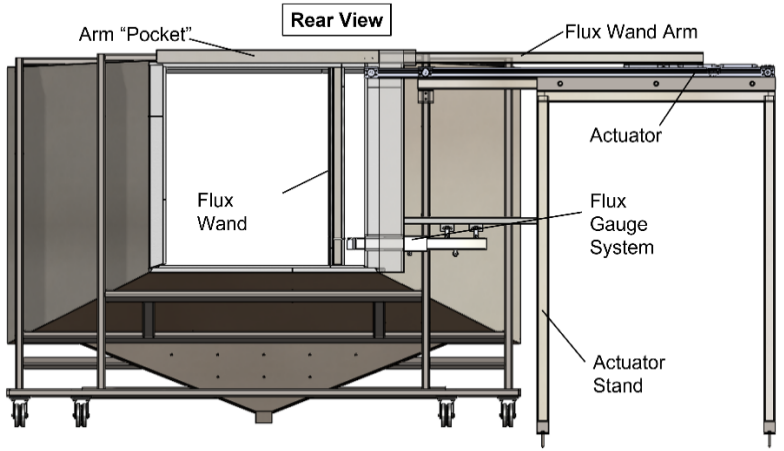
- The receiver uses a modular concept leveraging lessons learned from previous FPR iterations
  - Features a multistage design, SNOUT, and integrated flux wand
  - Designed to minimize downtime and repairs



Solid model rendering of the receiver assembly

Finite element simulations of the multistage receiver's nominal performance

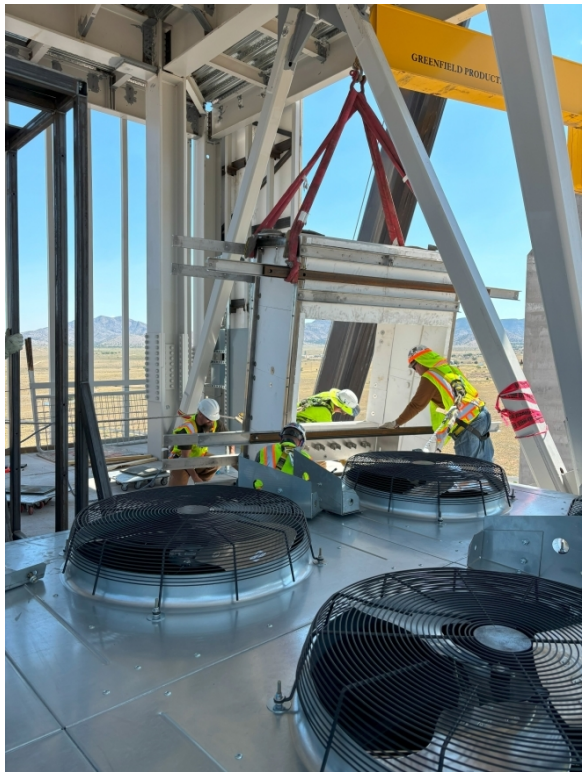




Integrated flux wand assembly
(to measure instantaneous flux on the cavity)

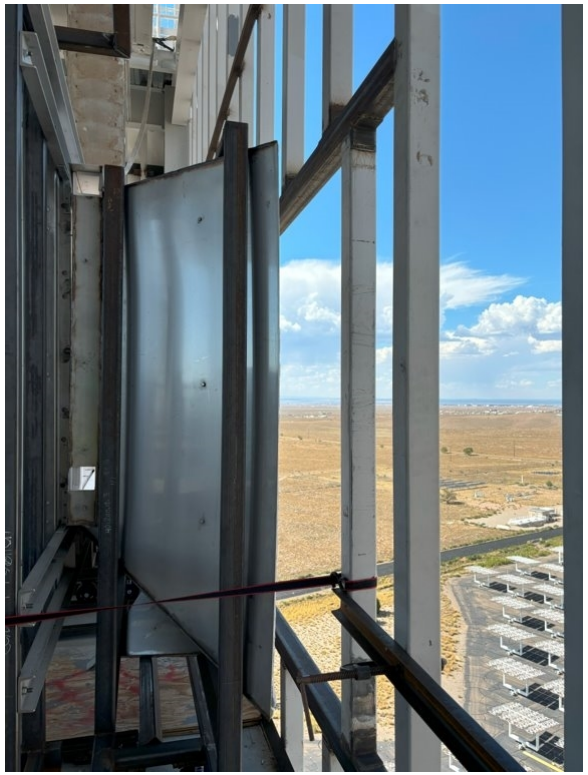
Receiver Installation

- The receiver system has been installed within the tower
  - Receiver installation is ongoing focusing on interconnection with the ducting



Receiver cavity being lifted into the tower

Receiver cavity mounted on a rail system

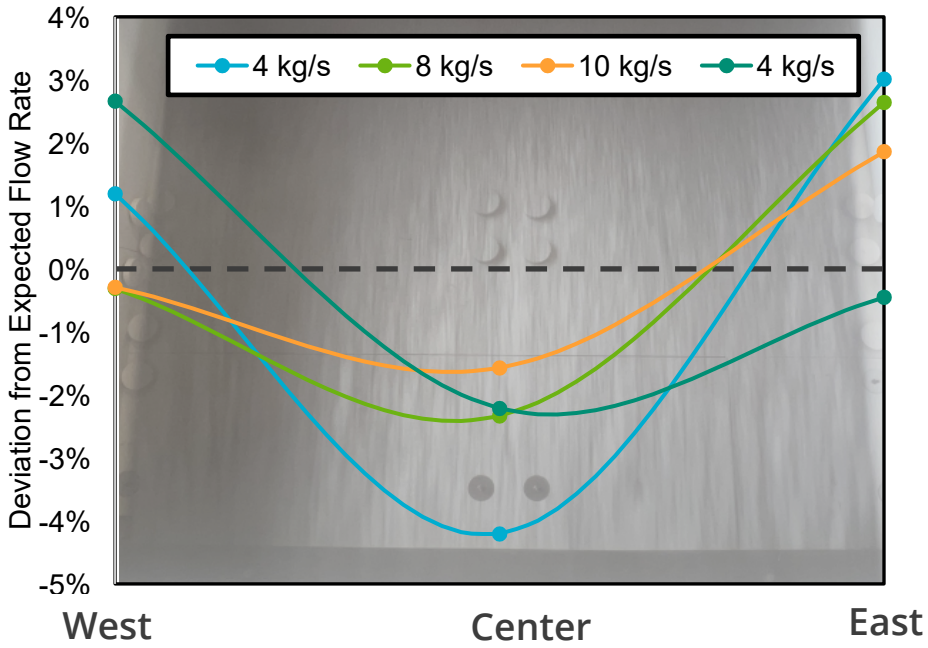


SNOUT interface with spillage board rails

Gravimetric receiver weigh hopper below the receiver cavity

Receiver Ground Test

- Achieved minimum and maximum flow rates (3-12 kg/s)
  - Maximum flow rates (20 kg/s) did not eject particles through the aperture
- Particles flowed through the cavity as expected
- Confirmed SCADA integration with receiver hardware
- Some mass flow rate deviation was observed across the curtain
  - Caused by stock material tolerances
  - Corrections have been made before the installation into the tower
  - PCGV valves may also be integrated as an alternative solution

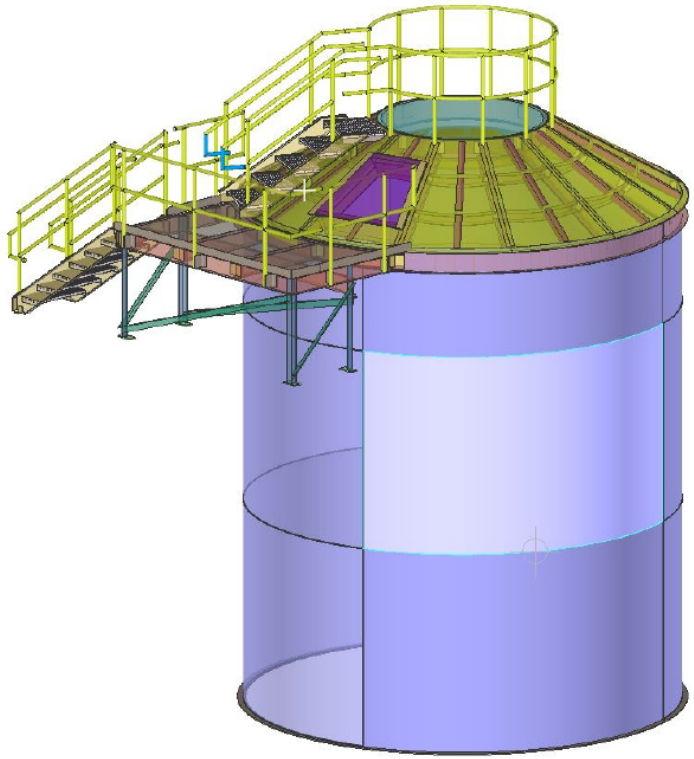


Thermal Storage

Storage Insulation Instrumentation

- 6 MWh two-tank thermal energy storage
- 122 metric-tons of CARBO HSP 40/70 particles
- Flat bottom tanks with particle riser

- Tanks installed bottom-up with structure construction
- Insulation installation on-going: Planned completion Oct. 2024



Flat Bottom Storage CAD Rendering

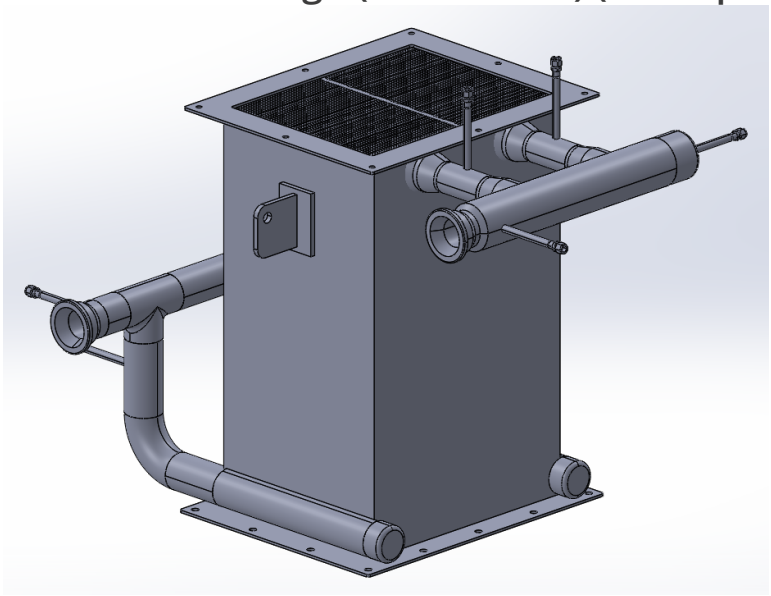
Insulation Installation Progress

Tank Delivery, Fabrication, and Installation

Heat Exchanger

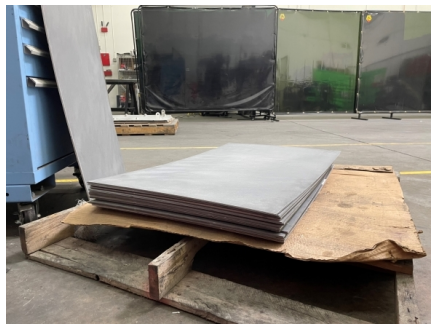
Primary Heat Exchanger

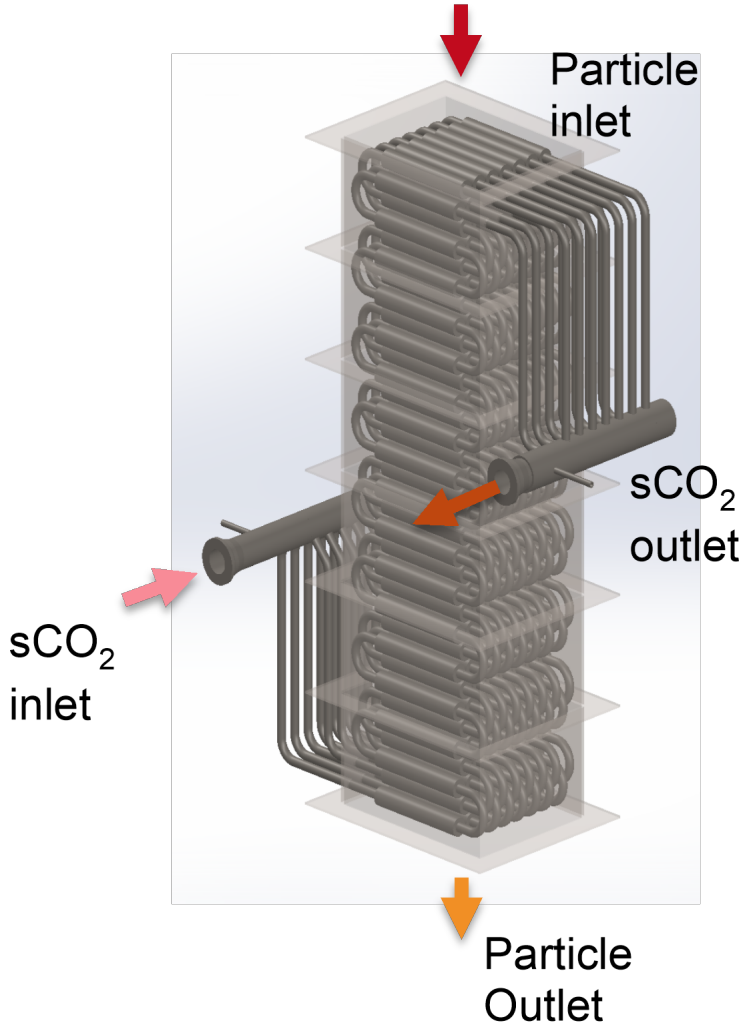
- G3P3-USA is awaiting delivery of two heat exchanger concepts
  - Parallel plate design (Inconel 625) (primary concept)
    - Currently experiencing fabrication delays
  - Shell and tube design (Inconel 625) (backup concept)



Parallel plate PHX core rendering

Shim assemblies prior to furnace loading (diffusion bonding)



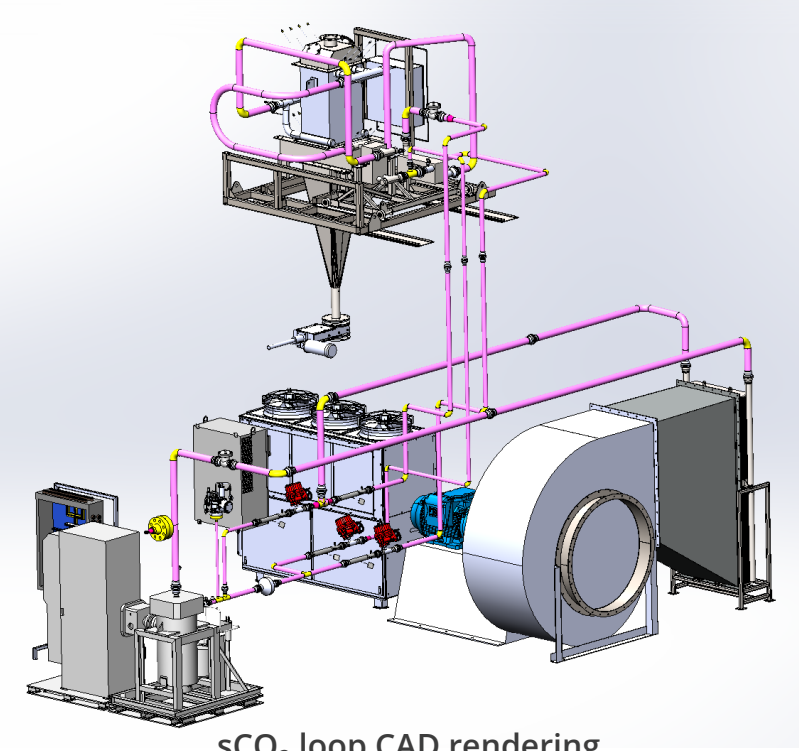


Shell and Tube PHX rendering

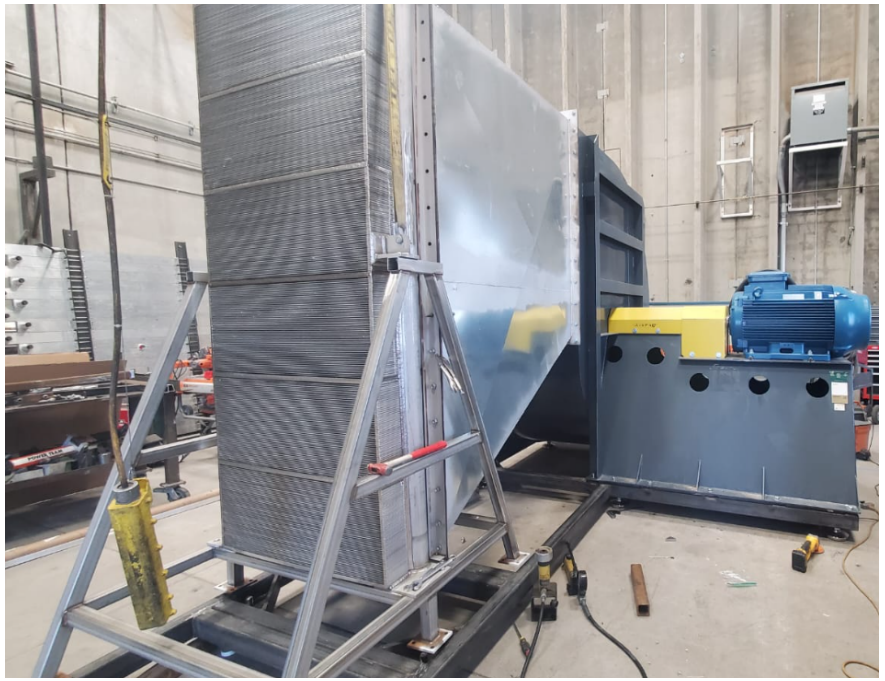
sCO_2 Loop

sCO2 Loop Design Update

- 1 MWt sCO2 heat rejection loop
- Serves as the heat rejection step in the gen3 CSP cycle – future augmentation to power cycle
- xi



sCO_2 loop CAD rendering



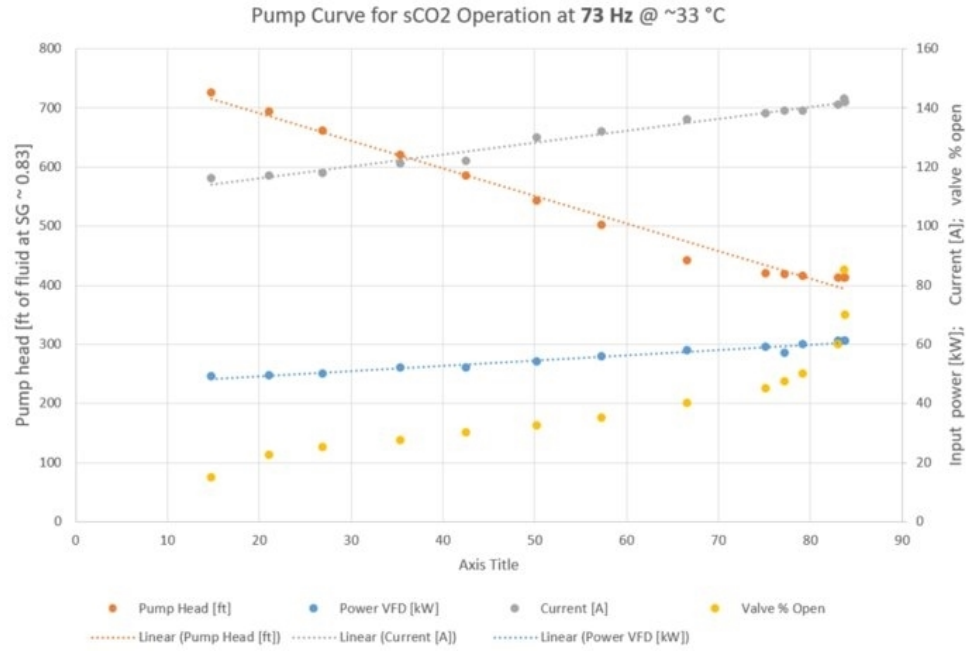
sCO_2 blower (right) and air cooler HX (left)

sCO_2 blower (heat rejection) (top) and sCO_2 pump (bottom)

sCO2 Loop Ground Testing

- sCO2 loop “cold” commissioned on ground prior to installation in G3P3 tower
- System pump and sensors characterized
  - Pump curve produced
  - Sensor ranges assessed
- Lessons learned
  - Venturi flow meter unsatisfactory – need for Coriolis flow meter
  - Pressure sensor differential measurement range too low – upgraded instruments needed
- Improved equipment procured
- Equipment installed in G3P3 tower

sCO_2 ground loop assembly during testing



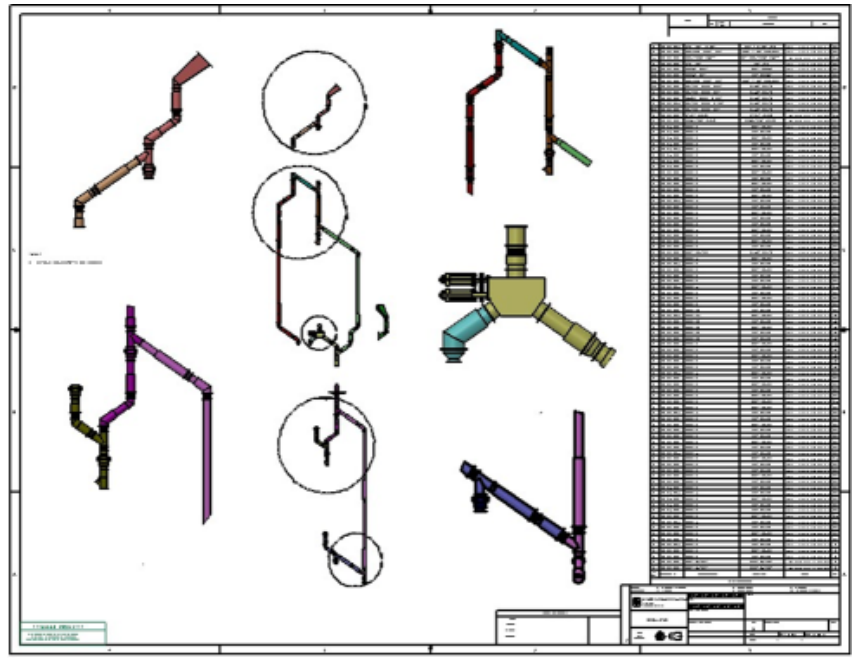
Balance of Plant

Ducting and Valves

- Circular ducting design chosen over square system
  - Minimizes the number of unique parts and fabrication
  - Simplifies design for thermal expansion
  - Simplifying mounting strategy – utilization of off the shelf hardware
- Ducting fabrication is underway

Dual actuation valve below hot storage

Testing of particle flow within the isolation valve

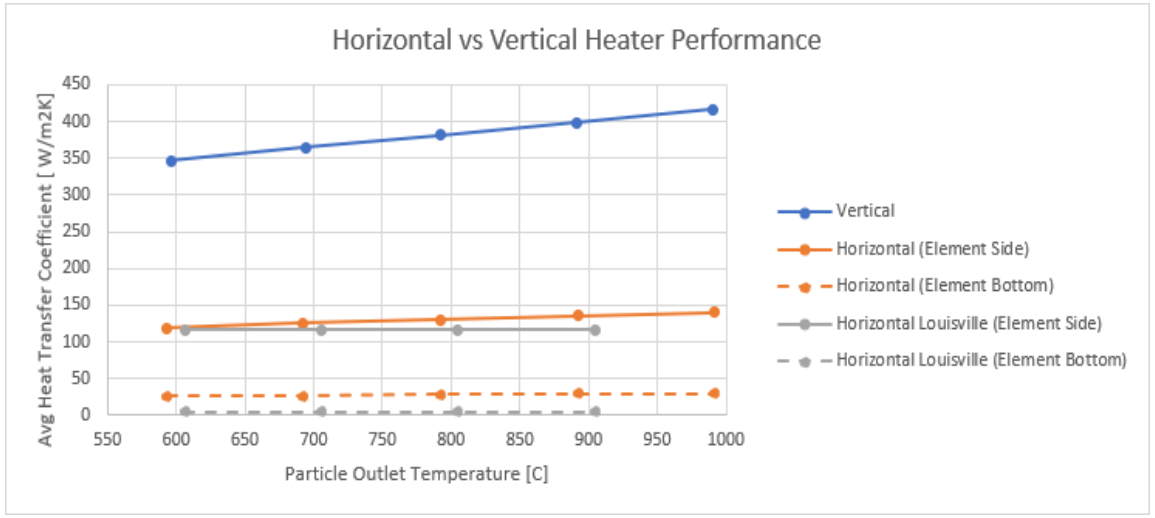


Completed interconnections

In house construction of the ducting system

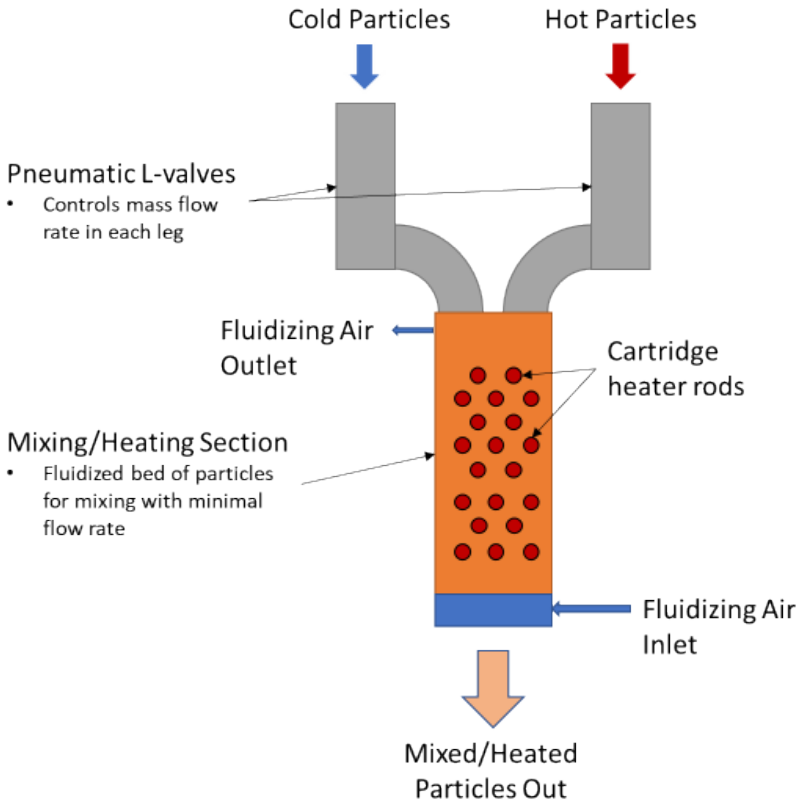
Electric Heating

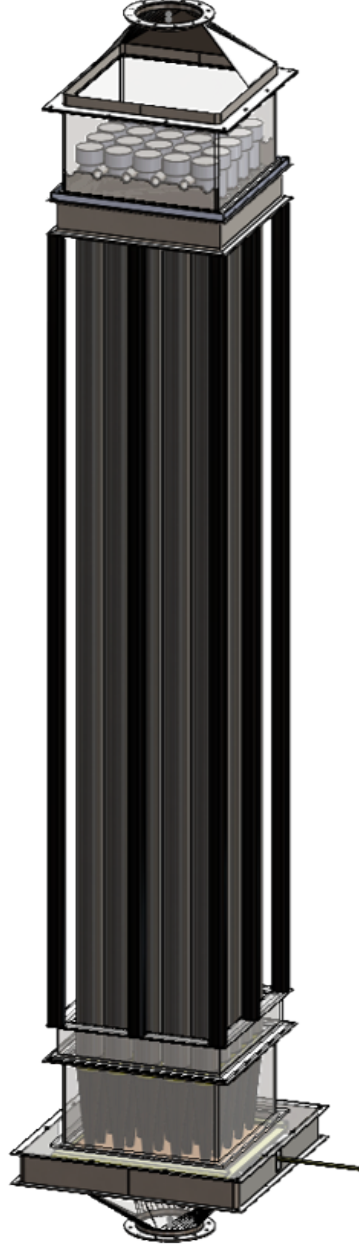
- Utilized for system pre-heating and particle temperature control
- 400 kW packed bed and 200 kW fluidized bed designs
- Designs completed and fabrication/procurement underway



Improved packed bed heater performance

Fluidized heater concept





400 kW heater CAD

Next Steps and Lessons Learned

Next Steps

What's Next?

- Complete ducting/insulation installation
- Install heat exchanger and complete sCO2 loop
- Setup SCADA system & calibrate valves/sensors
- Cold flow particles
- Gradually add heat to the system

Near complete G3P3 tower with the existing NSTTF Tower

Lessons Learned

- NEPA (ask for everything you might want in your wildest dreams)
- Slope of decks for standard construction vs. equipment positions
- Crane optimization
- Storage assembly and materials
- Review of construction drawings (formal vs. discussions/emails) and architect understanding of use (cutouts for ducts)
- Pressure system
- SCADA was a much larger software development project than anticipated LabVIEW plug'n'play (450% over)
- Ductwork being a dedicated component (NOT for CAD Jockies)
- Assembly and installation is very expensive
- Design code review
- Management reserve was critical

Thank You