

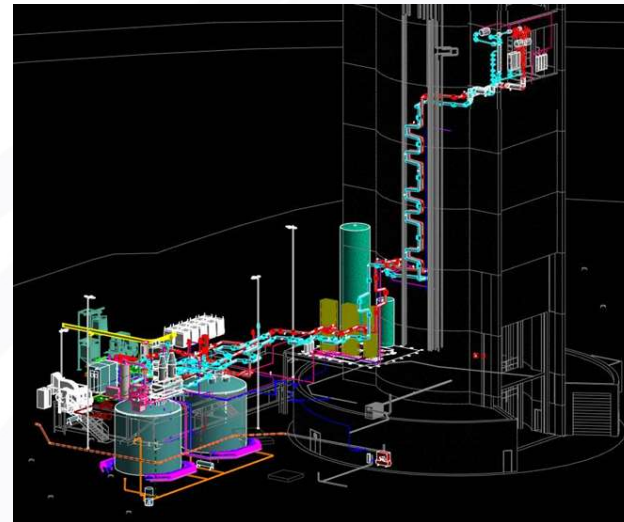


**SOLAR ENERGY
TECHNOLOGIES OFFICE**
U.S. Department Of Energy

Liquid-Phase Pathway Thermal Transport System

Gen3 CSP Summit
August 25, 2021

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Sandia National Laboratories



NREL Award # 34209 (agreement number)

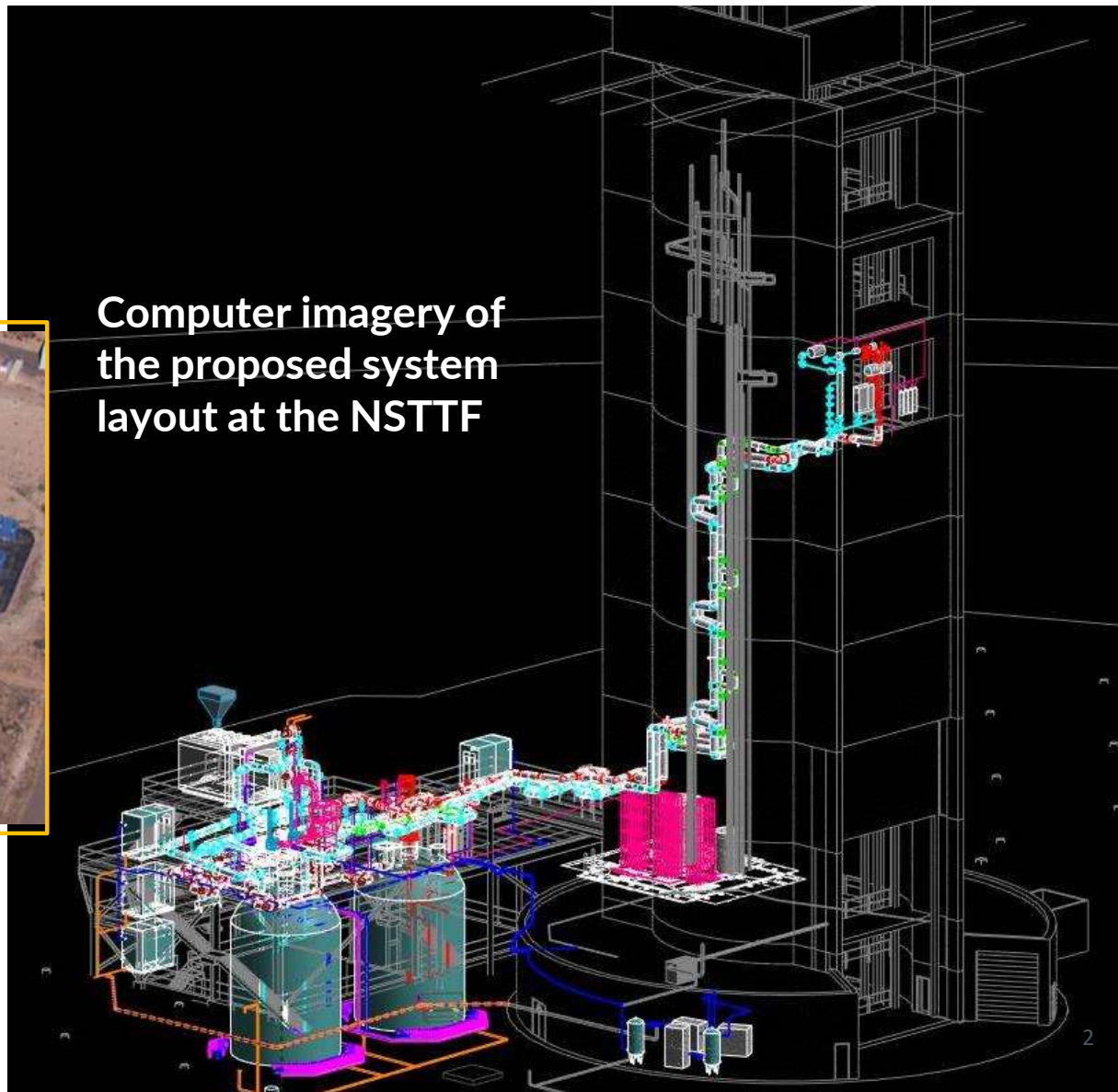
Gen 3 Pilot-System Design



National Solar Thermal Test Facility (NSTTF) at Sandia National Laboratories

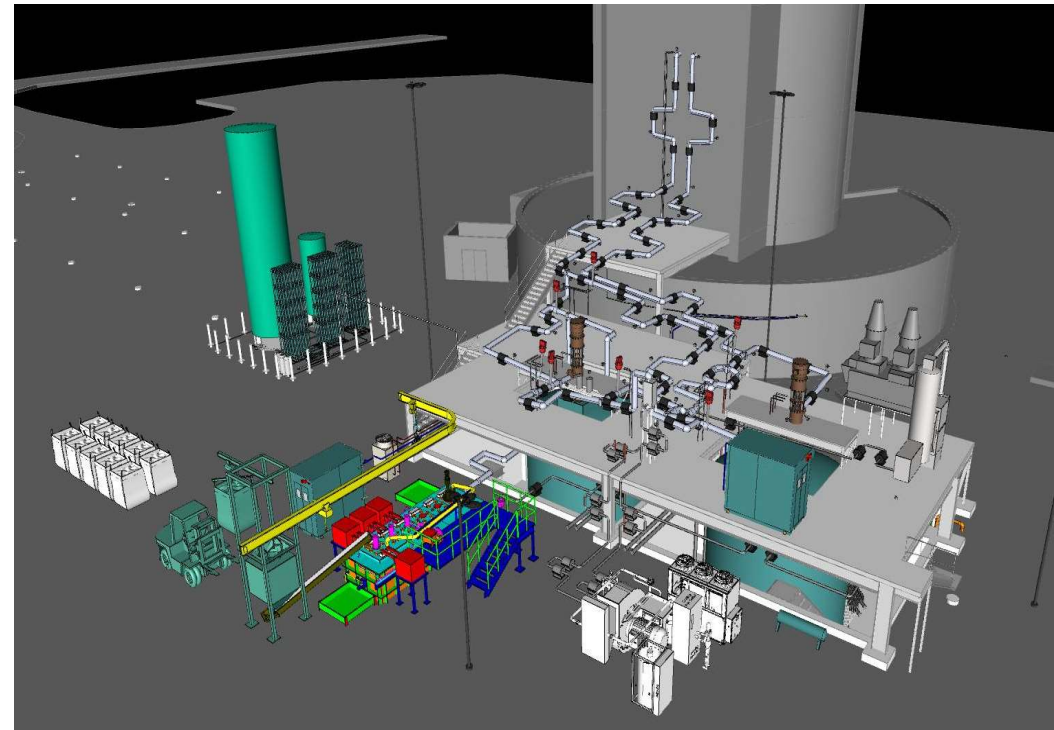
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Computer imagery of the proposed system layout at the NSTTF



Thermal Transport System: Key Challenges

- Heat tracing and freeze protection
- 700°C chloride salt pumps
- Control valves
- Salt-to-sCO₂ heat exchanger
- Controls and Ullage Gas System
- Higher-than-expected salt vapor pressure
- High salt vapor freezing phenomena
- Accommodation for MgO particulates



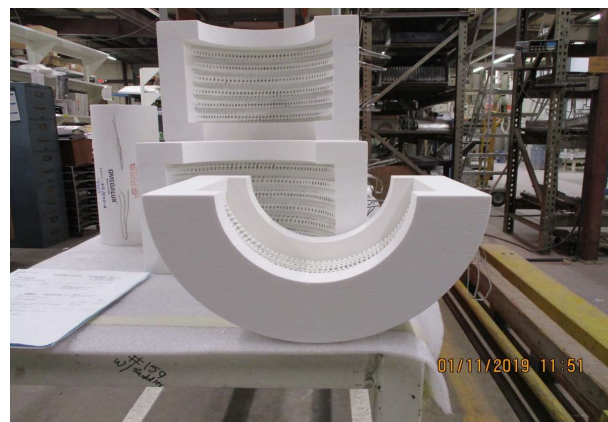
Piping, Heat Trace and Freeze Protection

Five types of pipe preheating systems, of which three: Mineral insulated (MI) cable, heat tape, and ceramic fiber heaters found to be viable for parts of the project need.

- Only one system, the ceramic fiber (CF) heater can be exposed continuously at $>720\text{ }^{\circ}\text{C}$ hot salt temperatures and not reduce the service life of the pipe preheating system.



MI cable installation for MSTL at Sandia.



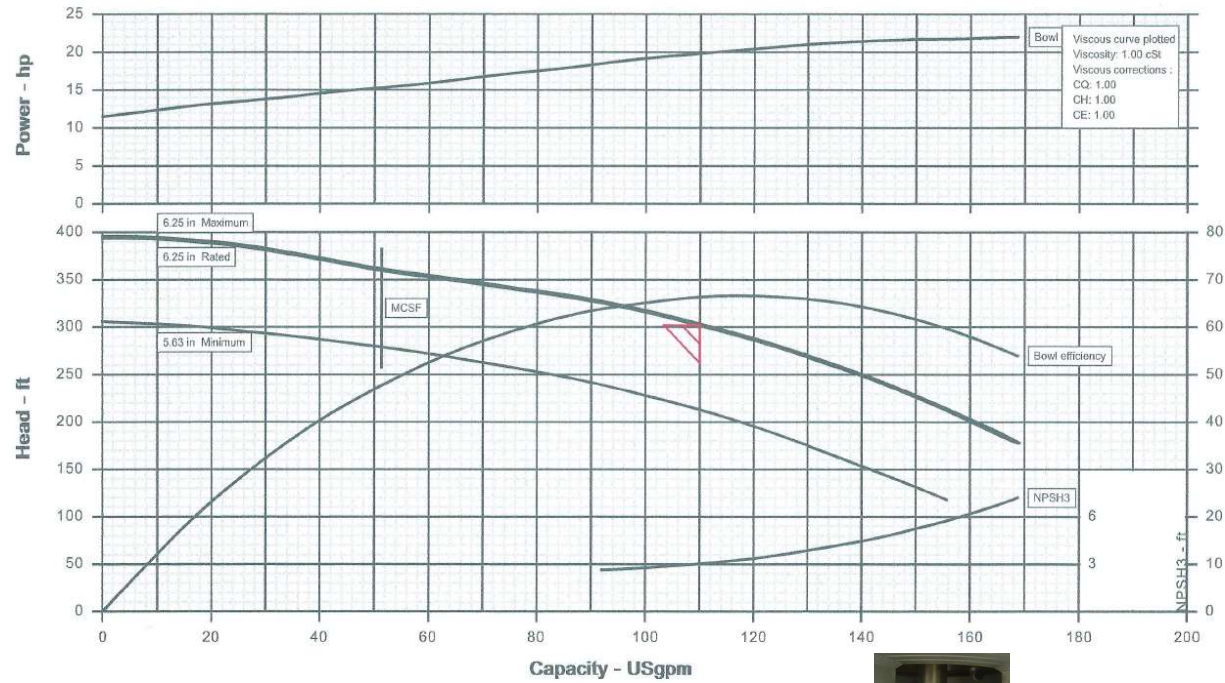
Thermcraft CF heaters



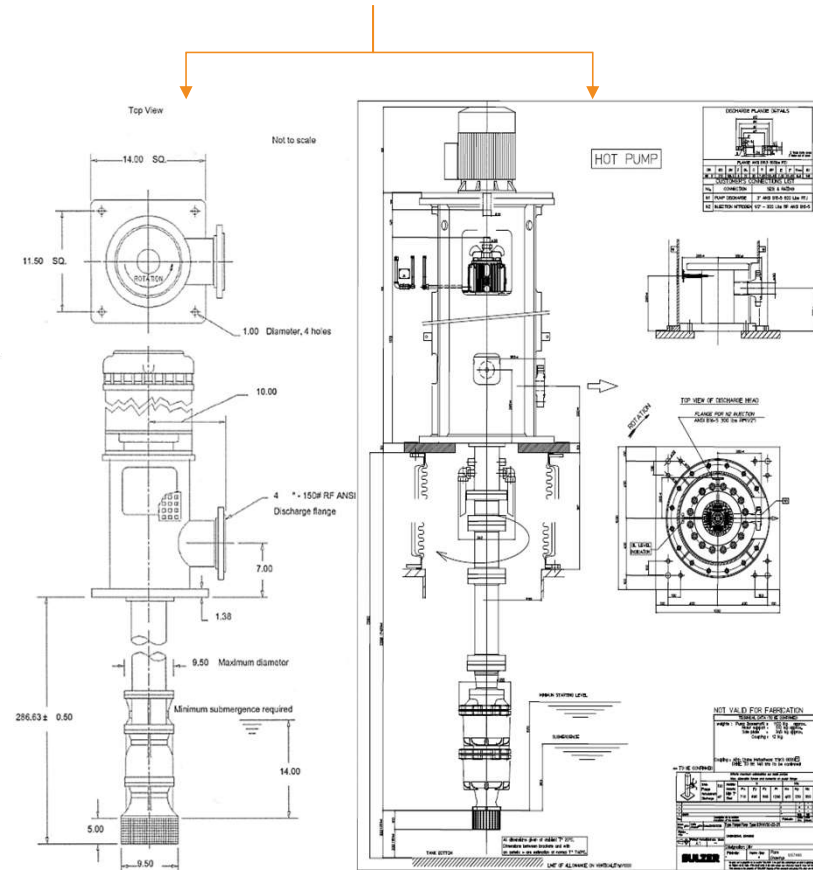
Pipe Heating System	Heater Initial Cost	Heater Installation Cost	Insulation Installation Cost
Ceramic Fiber	\$400-\$700 / ft.	\$75 / ft.	\$190 / ft.
MI Cable	\$150 / ft.	\$170 / ft.	\$388 / ft.

Salt Pump Curves

110 GPM, 302 ft., 110 TDH, 1720 RPM

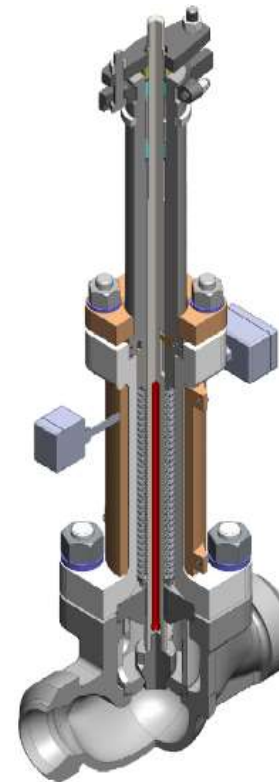


Collaboration w/ Pump Vendors & Project Teams for Gen 3 Pilot-System Down-Selection



Molten Salt Valves

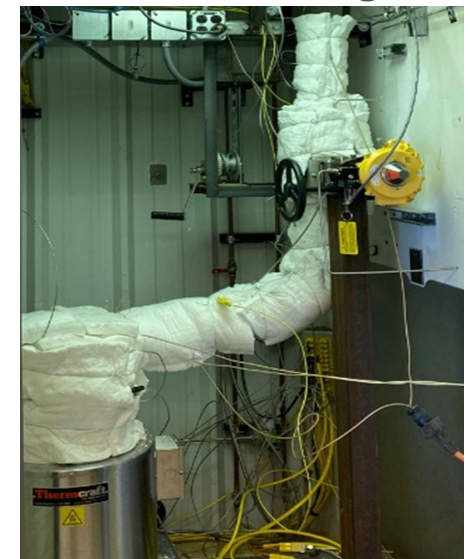
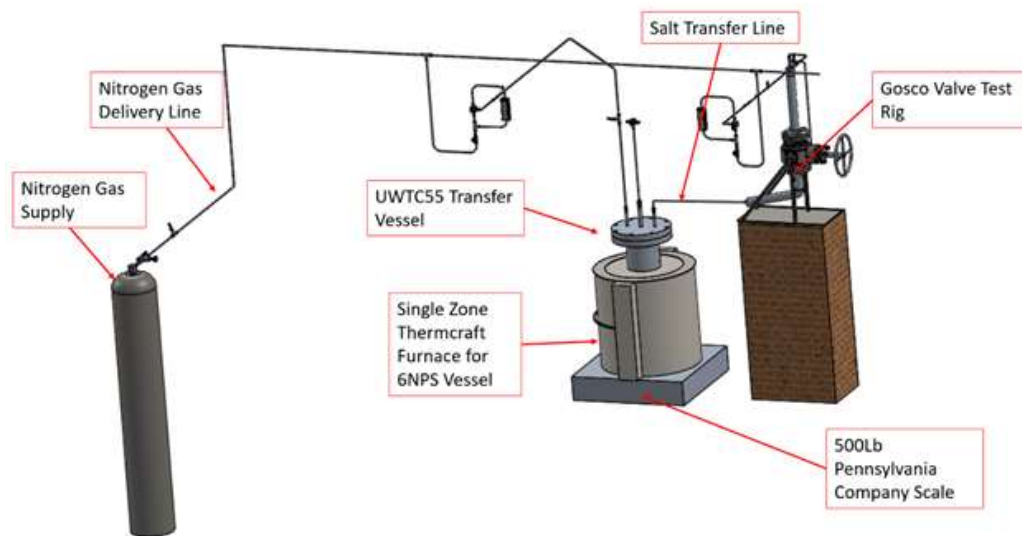
- The Gen 3 team interfaced with valve suppliers Flowserve, Guichon, Gosco, Samson, Trillium and Jarecki.
- Advanced chloride-salt valves based on designs with bellows seals and packing, similar to that used in nitrate salts.
- Funded DOE project to develop advanced valve, capable of freeze/leak-resistance up to 750°C.
 - Ternary-chloride salt materials were modified for chloride-salt service.
- High-temperature alloys and ceramics for valves construction.



Flow Control Valve
Image courtesy Samson.

Static Valve Testing

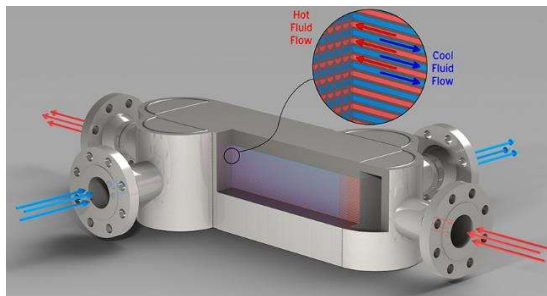
- Vendor C shut-off ball valve evaluation at Sandia NSTTF under static salt.
- Boronized-nitride recessed-groove ball to be compatible with ternary chloride salt.
- Graphite/Thermiculite Spiral-wound gasket to mitigate leakage from the valves raised-faced flanges.
- Efficacy testing was performed to evaluate the valve's ability to actuate 10 times at successive temperatures up to 720°C without leakage, actuation issues and seizing.



Heat Exchangers (HEX)

Salt/sCO₂ HEX

- Sandia and VPE designed diffusion-bonded HEX for salt/sCO₂
- Printed-circuit heat exchanger (PCHE)
- Divided into hot (Alloy 617) and cold (SS316) sections
- Ability to pass < 250 μm MgO particles
- Unit cost estimated by project member VPE



Na/Salt HEX

- ASTRI designed single counter-flow HEX for sodium/salt
- Vertical for drainage
- Could be split to two or more heat exchangers to minimise height
- Designed as a Vertical 1:1 TEMA E STHE heat exchanger as follows:
 - Sodium on the tube-side (min/max velocities: 1.2/2.5 m/s);
 - Salt on the shell-side (min/max velocities: 0.5/1.5 m/s);
 - Design simplicity and robustness;
 - Wide range of operational temperatures and pressures;
 - Tilted baffles to facilitate drainage on the shell-side.

