



Transient Heater Analysis for Orion Thermal Vacuum Testing

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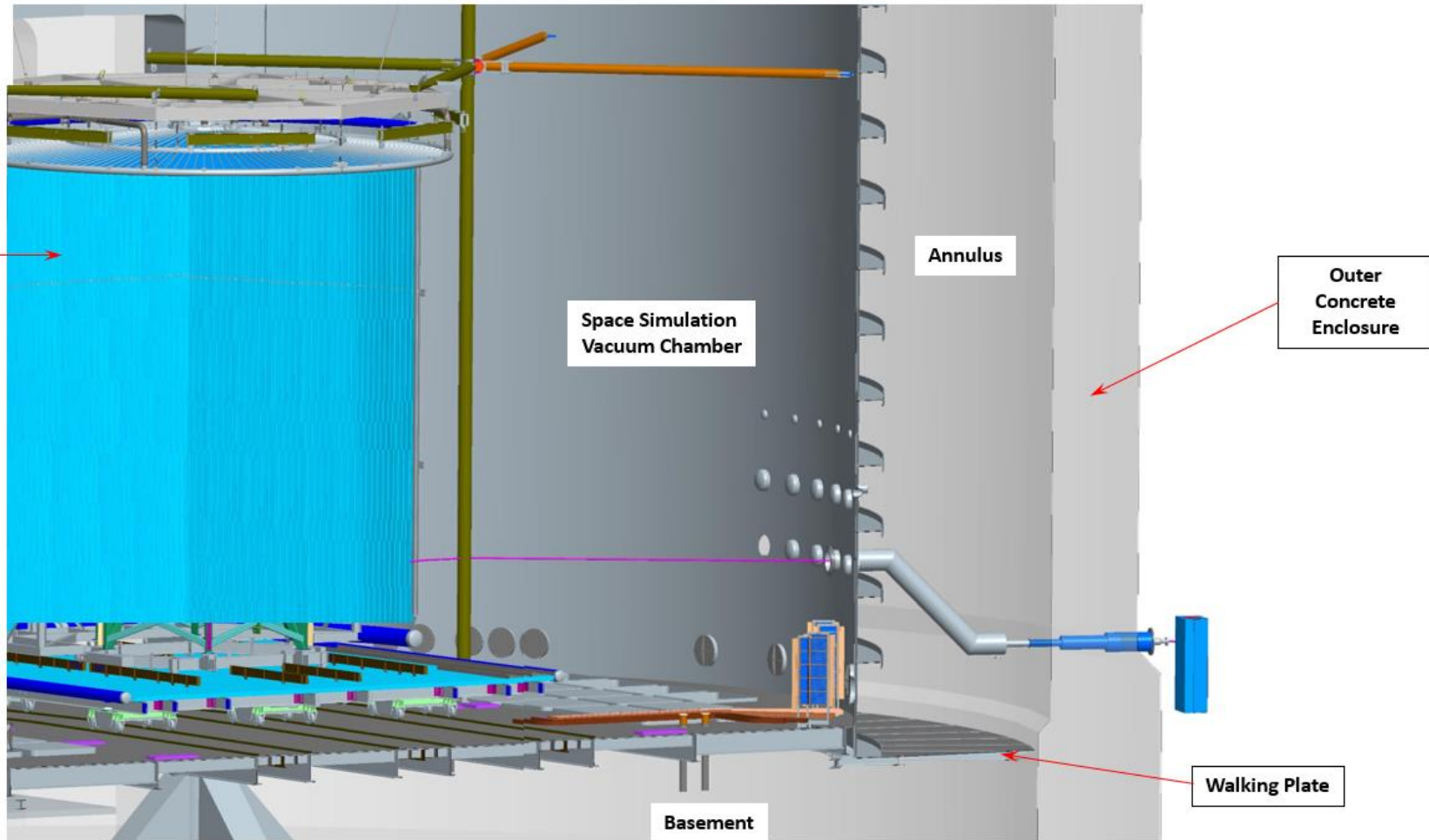
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Houston, TX

- Background
- Approach
- Model
- Results
- Conclusions



- Orion Multi-Purpose Crew Vehicle (MPCV)
 - Developed for future spaceflight missions (EM-1, EM-2)
- Thermal Vacuum Testing at Plum Brook Station (2019)
 - Space Environments Complex (SEC)
 - Space Simulation Vacuum Chamber
 - 122 ft. height, 100 ft. diameter
 - 60-day test







Approach



- Used Thermal Desktop to model and simulate SEC during T-Vac testing
 - To determine temperatures that will be reached in various areas in SEC during testing
 - Chamber, cryoshroud, outer concrete enclosure, basement, GN₂ piping, etc. all included
- Results from initial analysis of SEC model
 - Showed the chamber floor to reach very low temperatures (below -20°F)

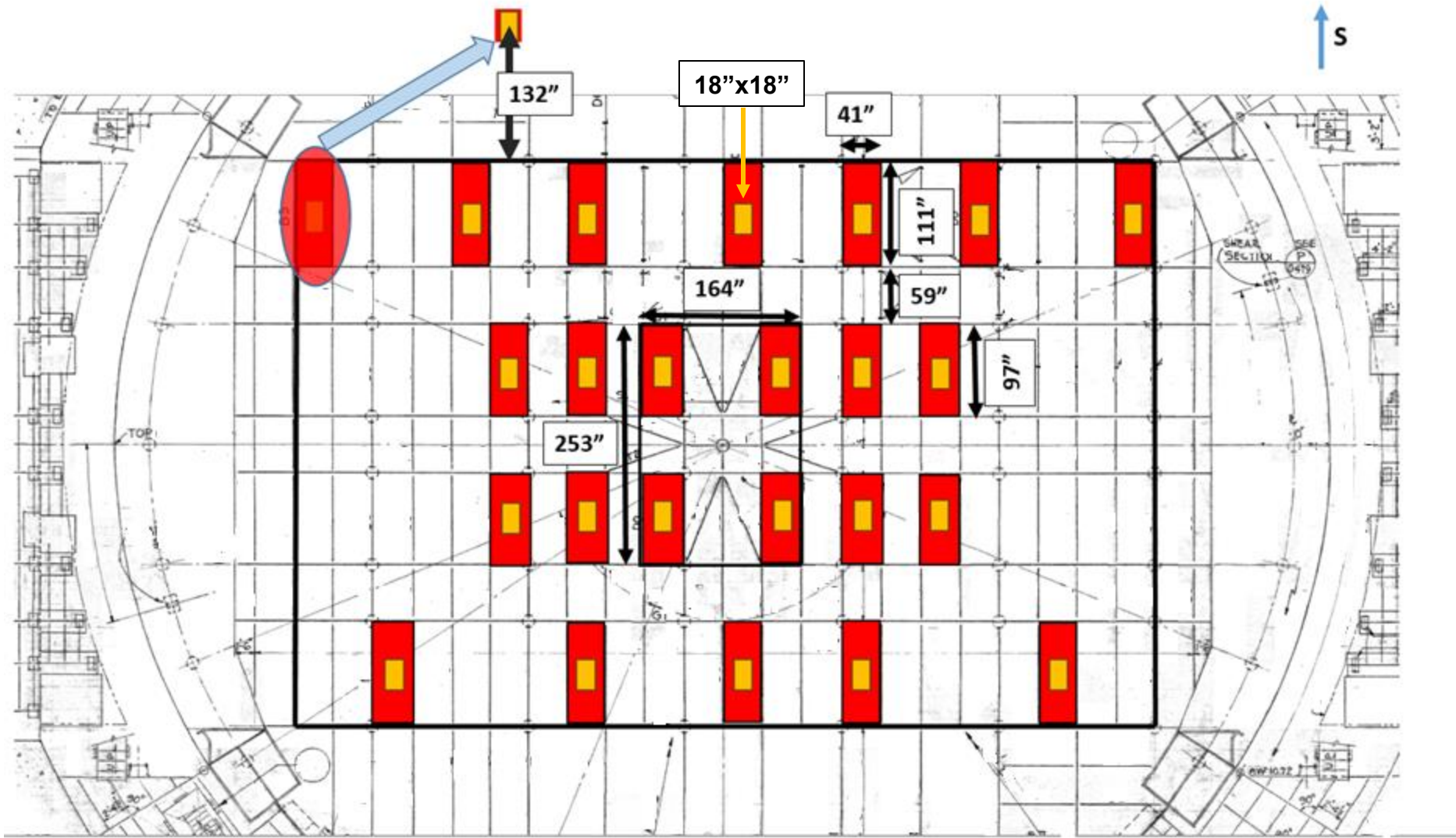


Problem

- Hardware located near the chamber floor needs to be maintained above minimum operating temperature
 - Elastomeric seals, Capralon bearing pads (-20°F), O-rings, etc.
- Ways to prevent the chamber floor from reaching these temperatures
 - Add patch heaters to colder areas of chamber floor (pipe penetrations)
 - Add insulation to GN₂ pipes in the basement

- OMEGALUX silicone rubber fiberglass heaters
 - Lightweight, thin, insulated, flexible
 - Size: 18" x 18"
 - Power: 1600 W
 - Watt Density: 5 W/in²
- Heaters installed in bays located underneath chamber floor



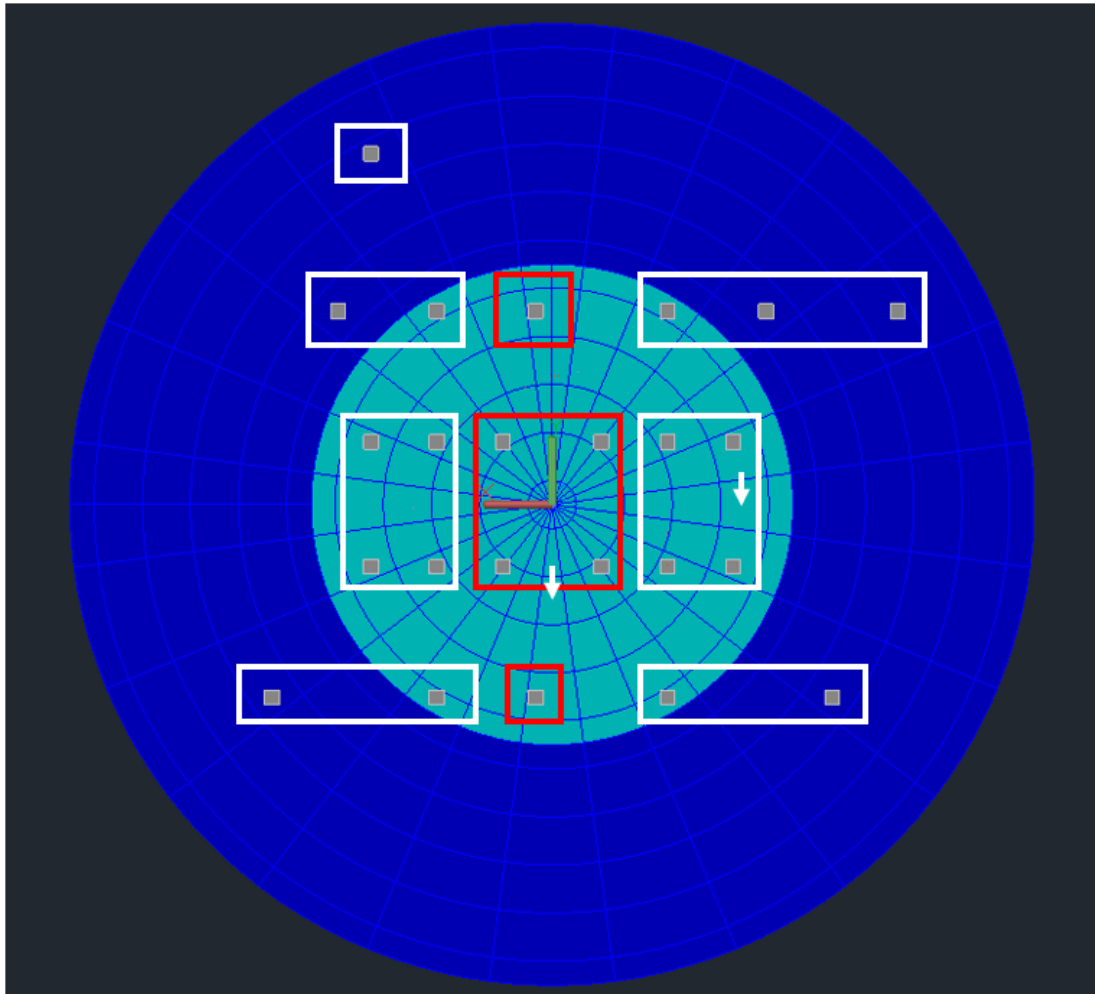




Heater Zones & Controllers

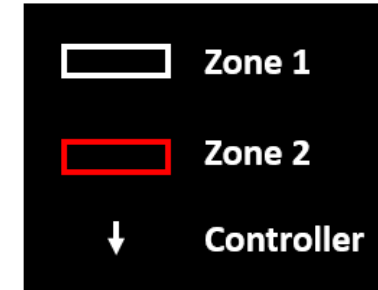


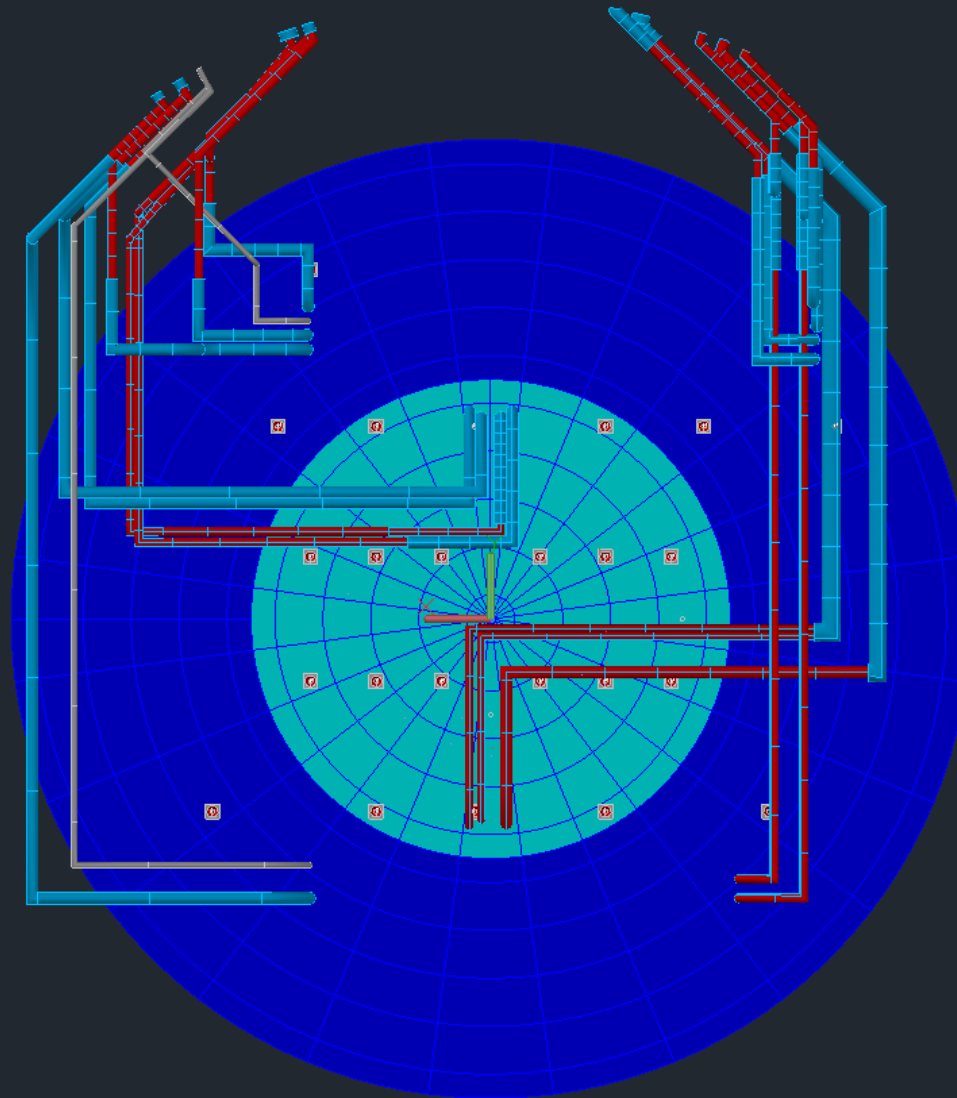
- 2 controllers were used to control operation of heaters
- Heaters turn on and off based on the temperatures of their sensing nodes (or controllers)
 - Turn on when sensing node temp $< 40^{\circ}\text{F}$
 - Turn off when sensing node temp $\approx 50^{\circ}\text{F}$
- Ran steady & transient Case
 - 30-hour case
 - Heaters set to 0% power during steady-state
 - Heaters set to proportional mode during transient



• 24 Heaters

- 1600 W
- On temp = 40°F
- Off temp = 50°F

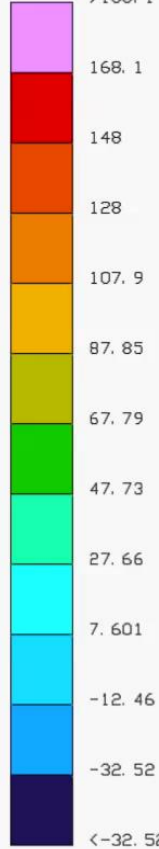




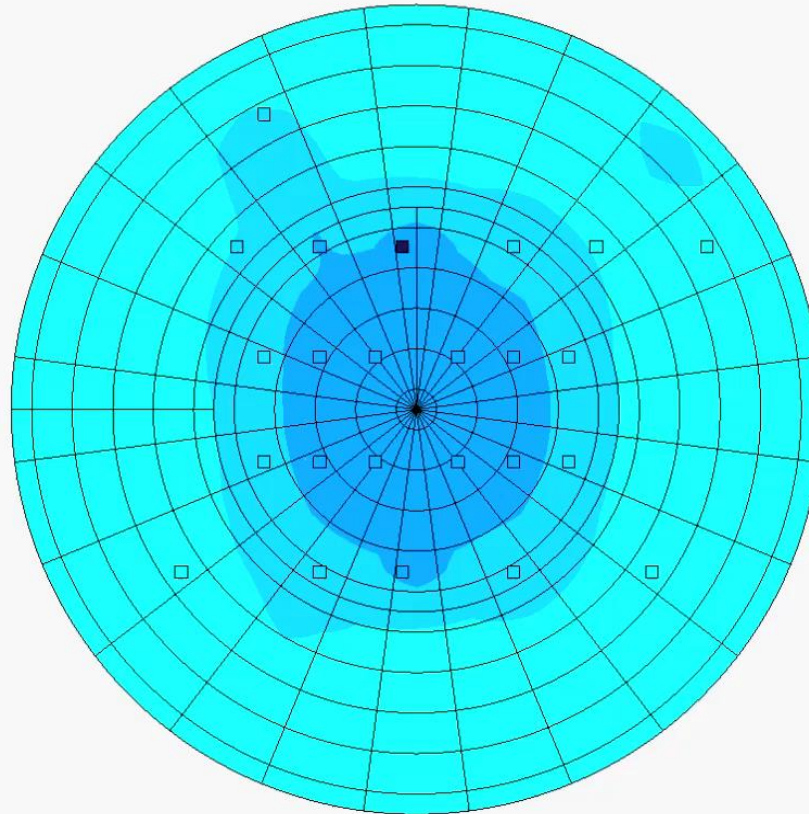


RESULTS

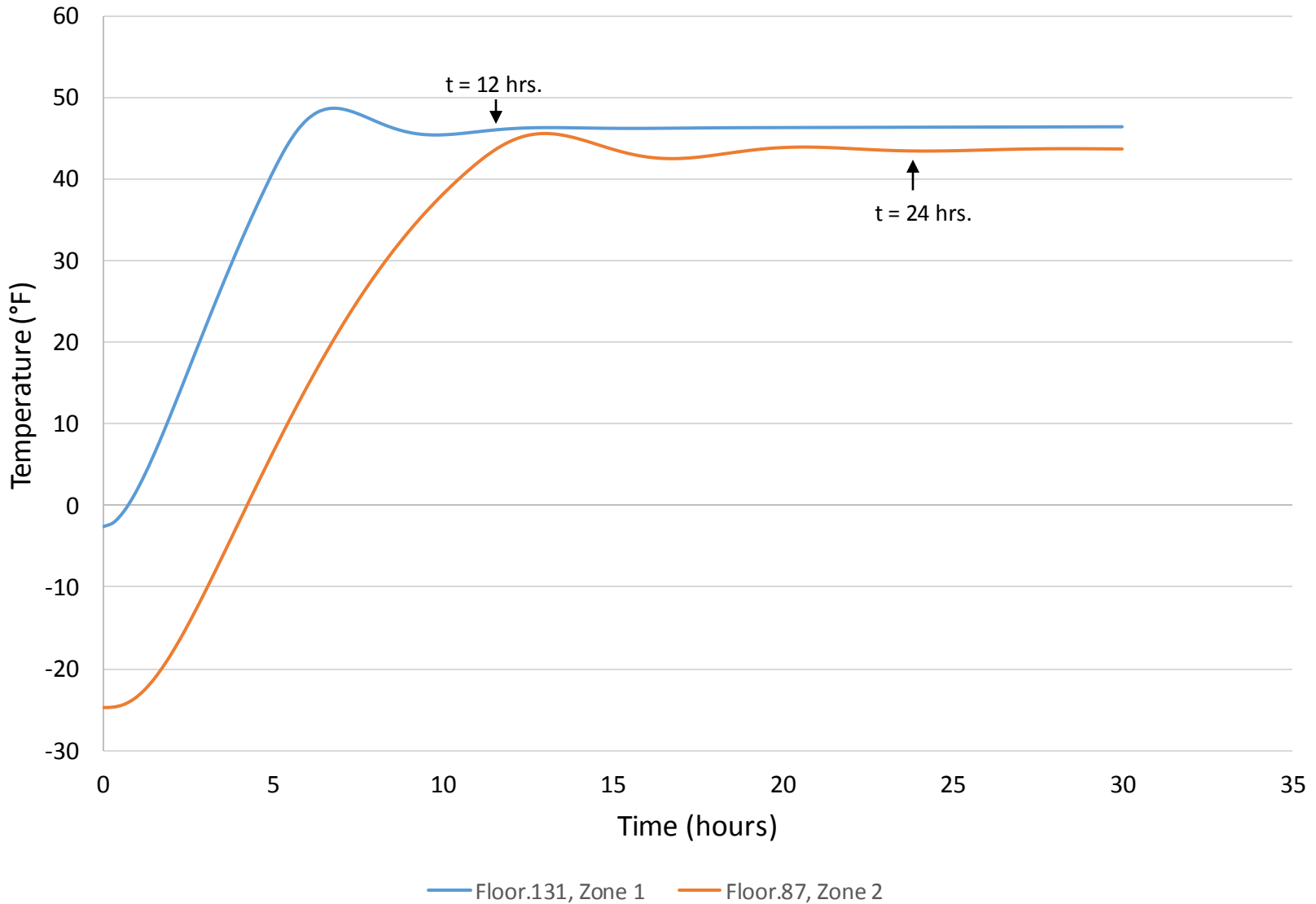
Node



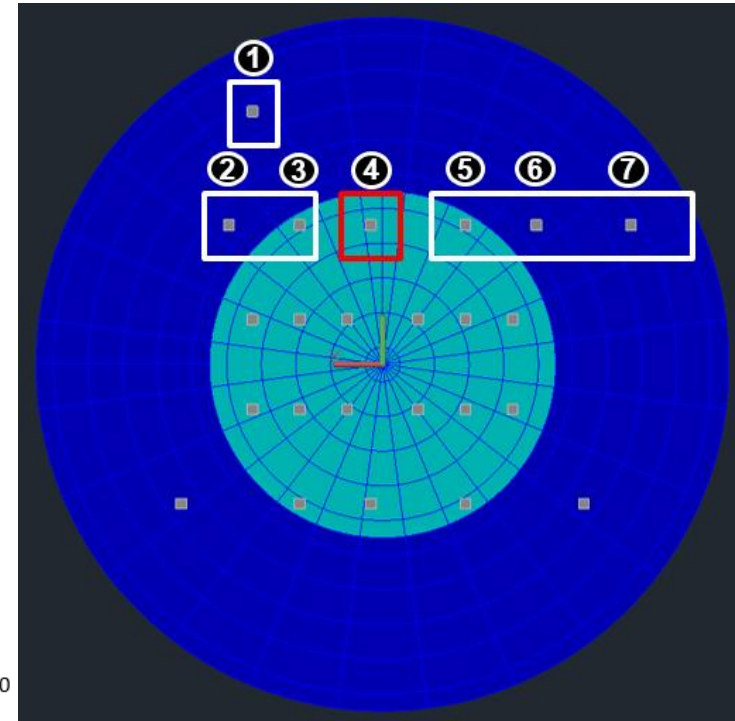
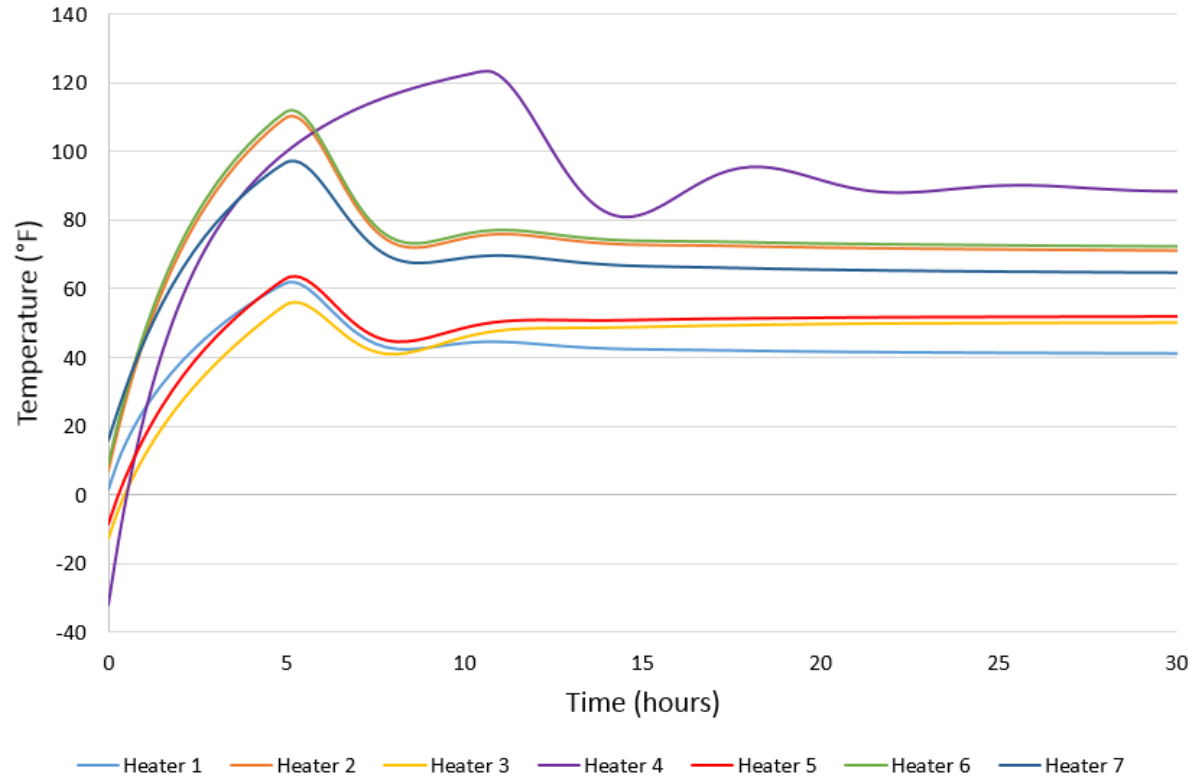
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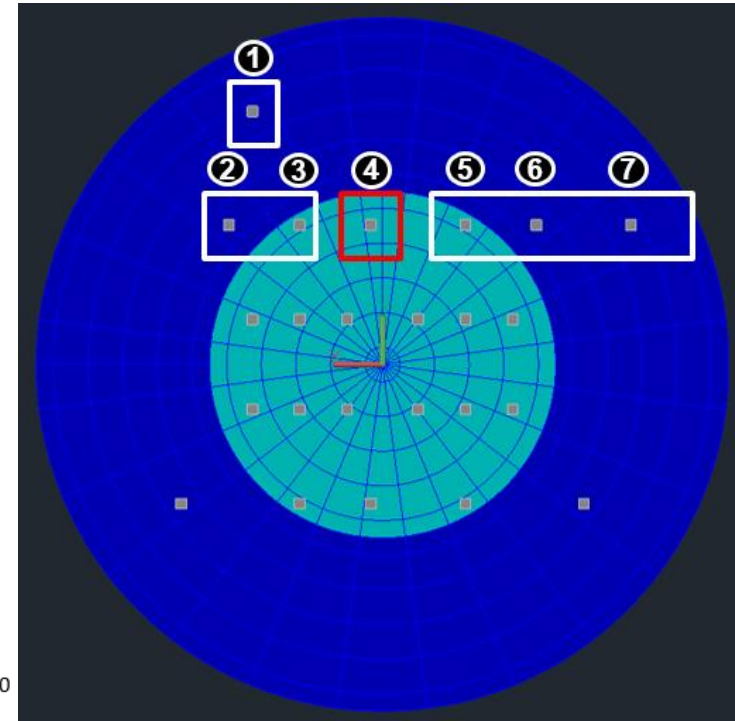
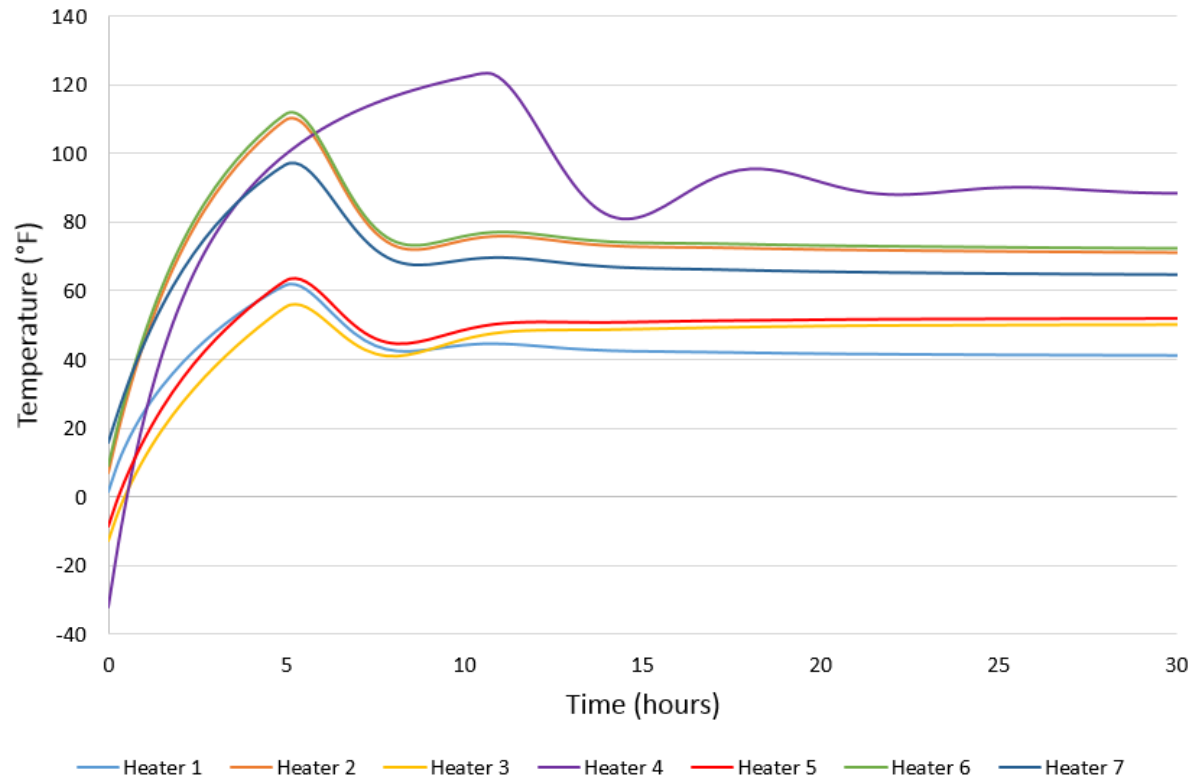
Temperature [F], Time = 0 hr



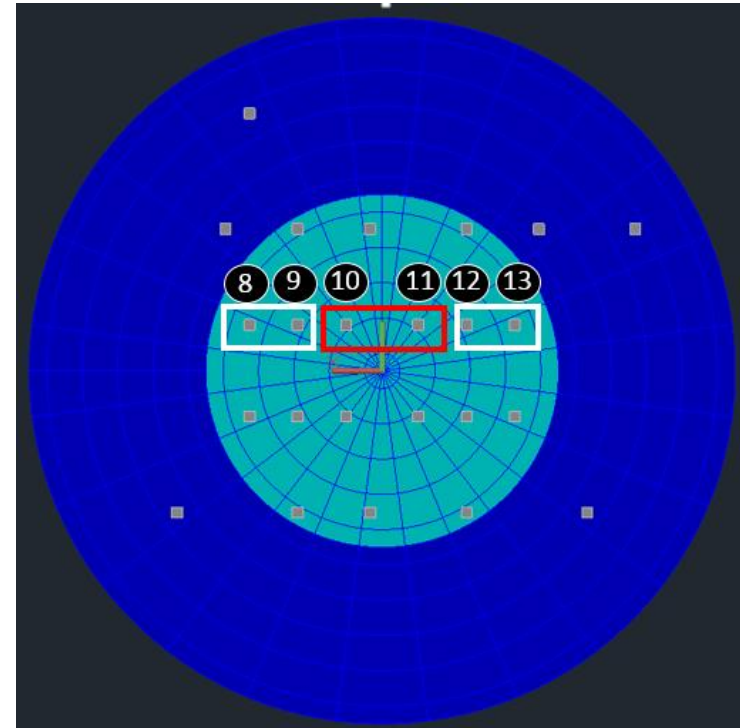
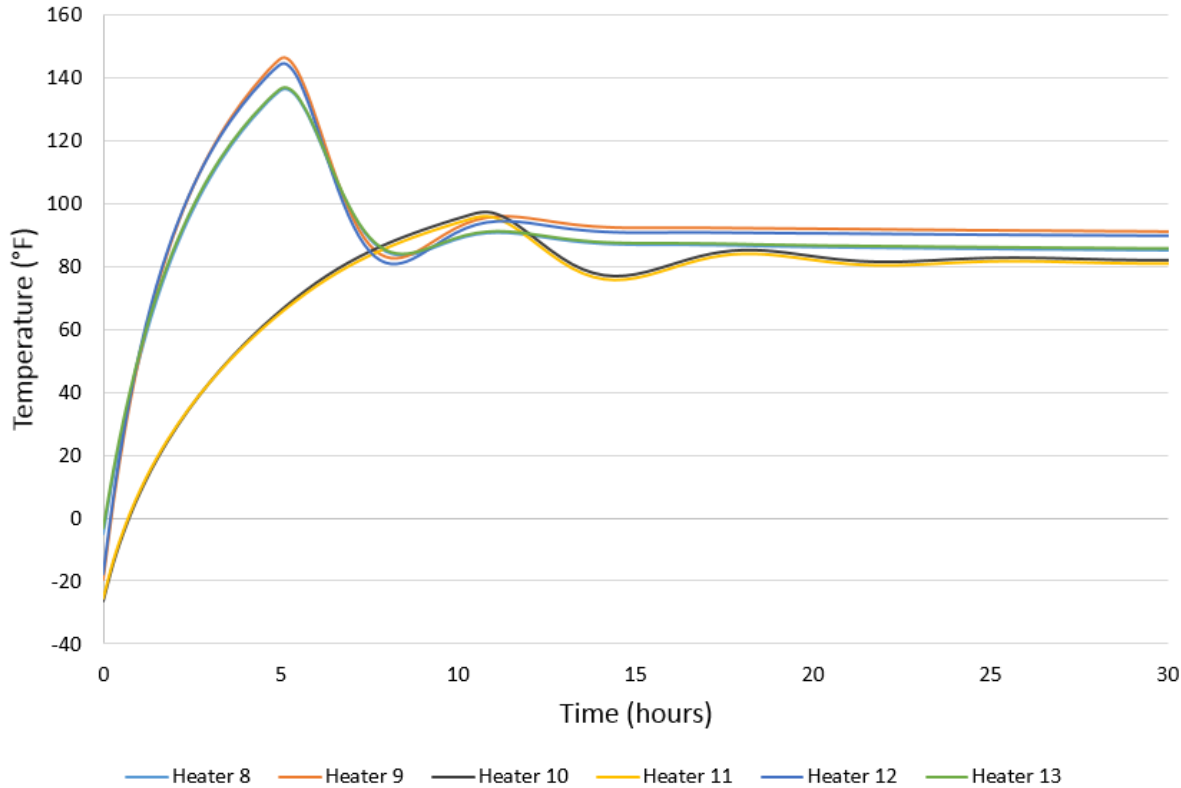
Transient Heater Response



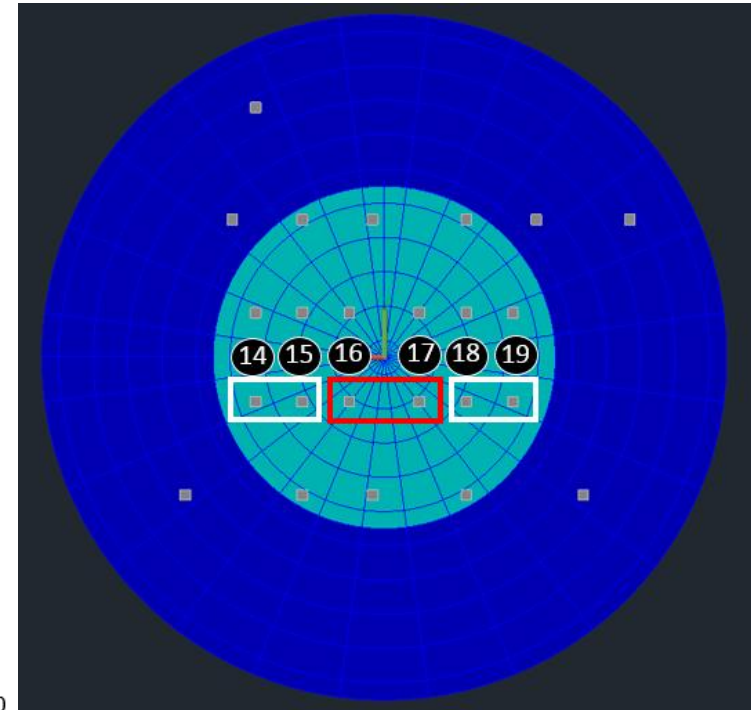
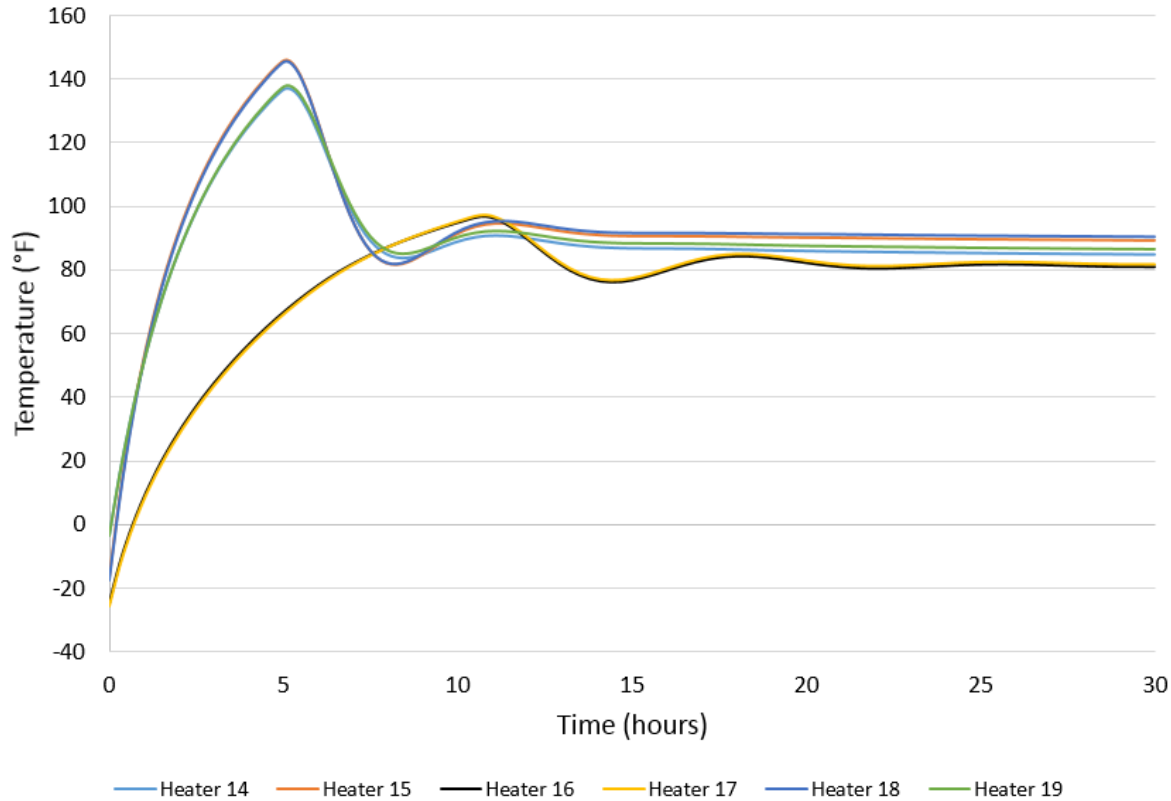
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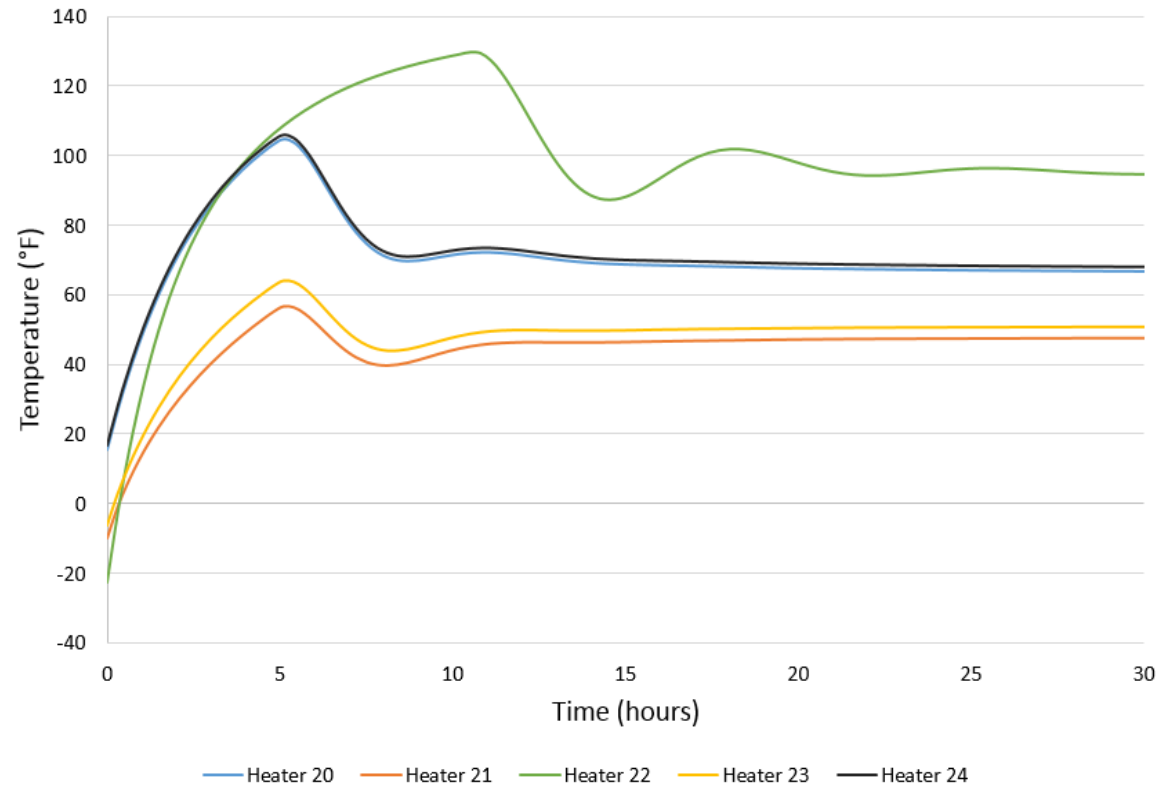
Transient Heater Response



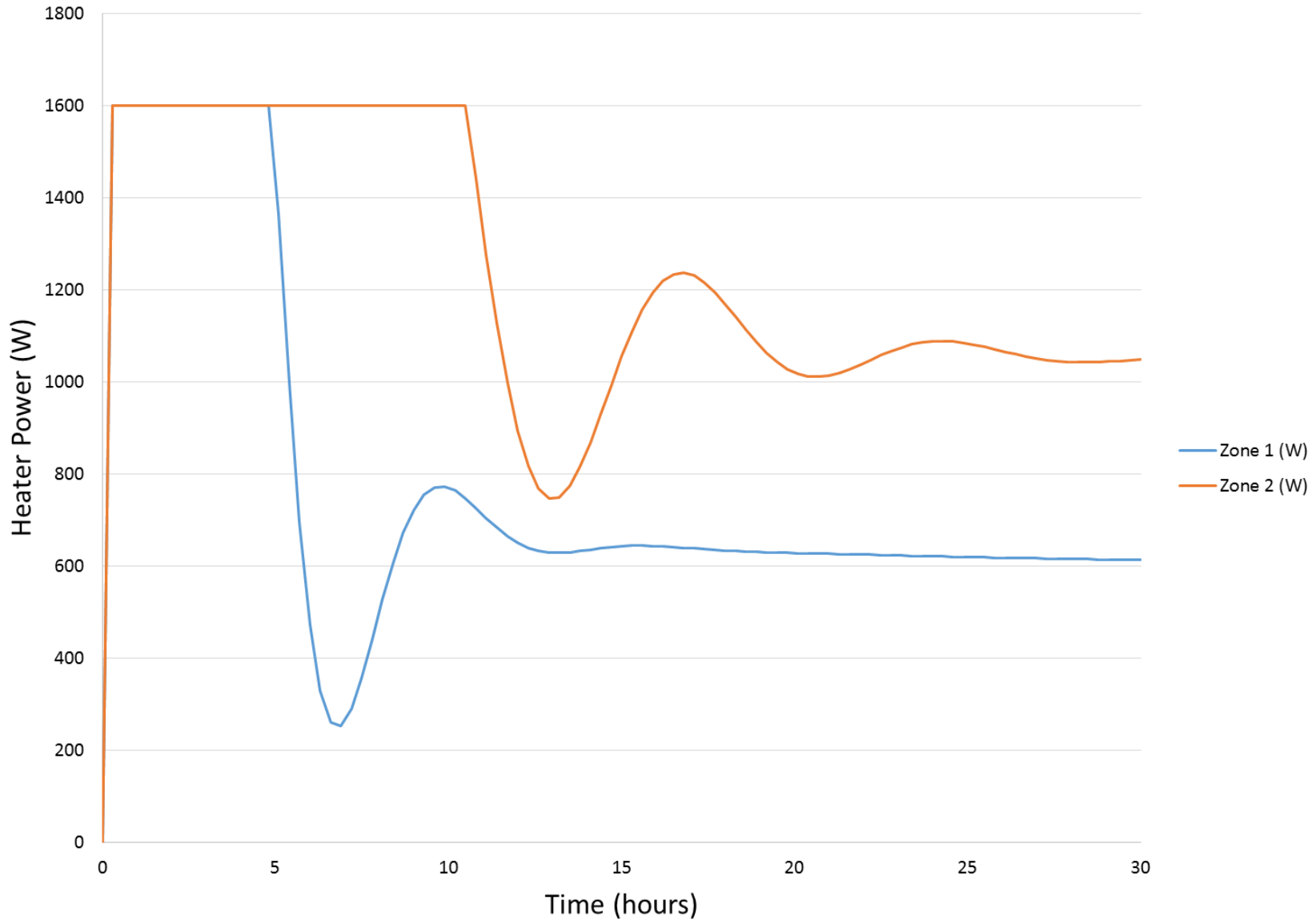
Transient Heater Response

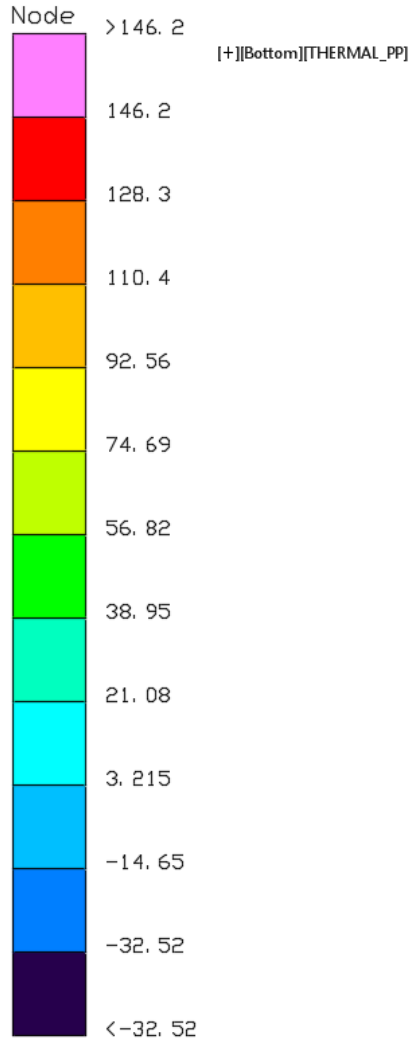


Transient Heater Response

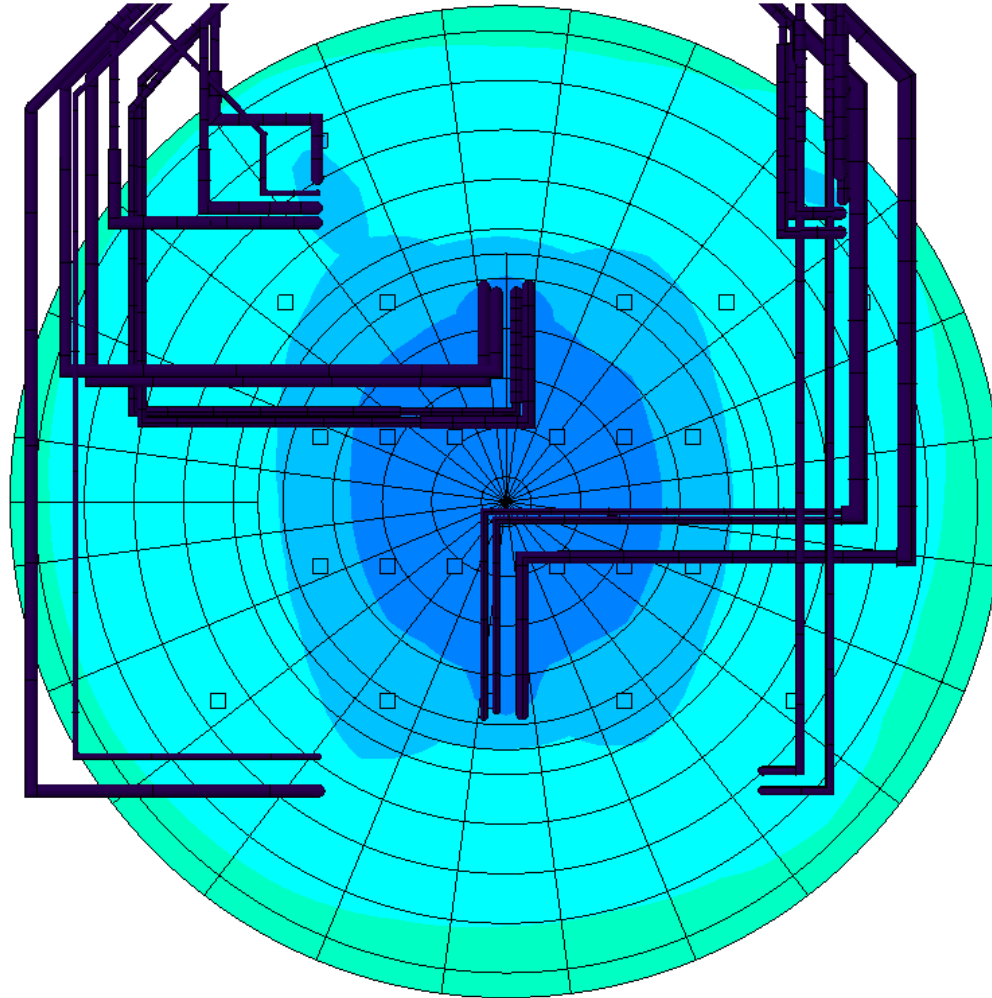


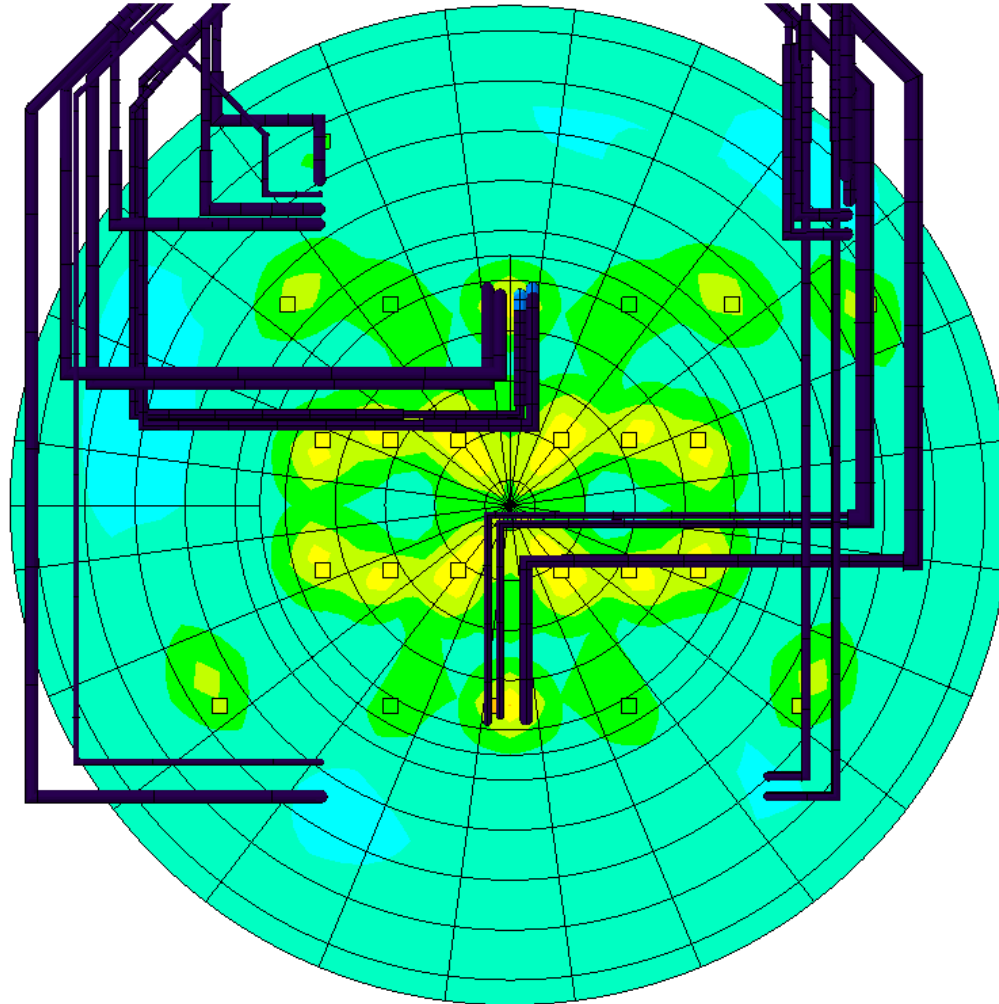
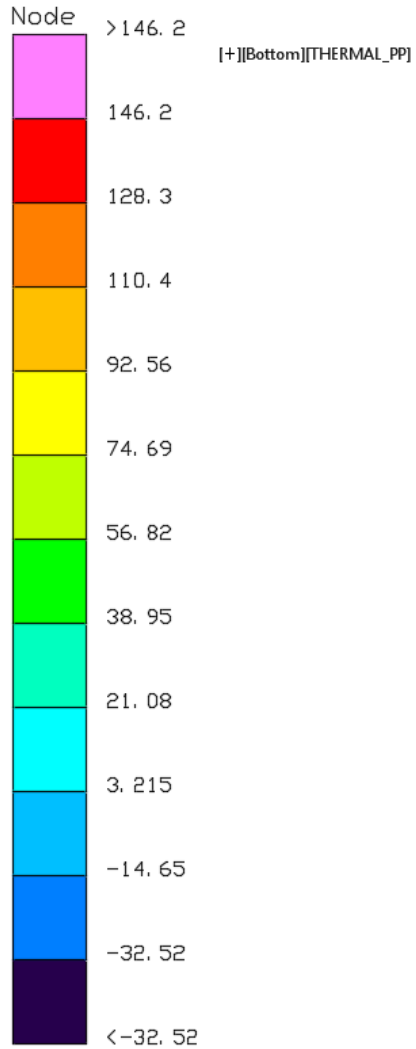
Heater Power vs. Time





Temperature [F], Time = 0 hr





Temperature [F], Time = 30 hr

- Heaters had significant effect on chamber floor temp.
 - Able to observe effect by setting heaters to 0% power during steady state and proportional during transient
 - Min. temp. on chamber floor at end of run = 13°F
- Analysis shows that chamber floor temperatures will remain above -20°F when heaters are used
 - Min. operating temp. of hardware vital to T-VAC test
- Able to determine optimal configuration of heaters
 - Optimal location of heaters and controllers
 - Heater power kept within its limits (1620 W)
 - Heaters able to reach steady state within 30 hours



QUESTIONS