

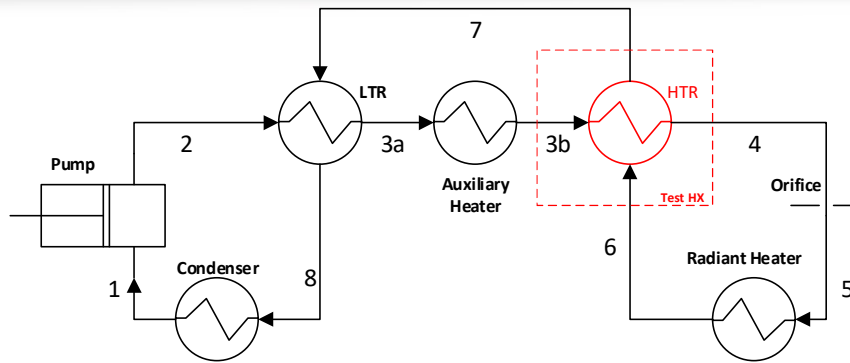
The logo for ECHOGEN power systems is a large, vertical rectangle with a color gradient from dark red at the top to orange at the bottom. The text "ECHOGEN" is written in a bold, white, sans-serif font at the top, and "power systems" is written in a smaller, white, sans-serif font below it. The background of the slide features a complex network of thin grey lines and small squares in black, orange, and grey, resembling a circuit board or a data network.

ECHOGEN
power systems

ARPA-E HITEMMP Heat Exchanger Test Loop

March 30, 2022

Test Loop – 800°C / 8.0 MPa Configuration



State	Description	Temperature (°C)	Pressure (MPa)	Enthalpy (kJ/kg)	Mass Flow (kg/s)
1	CHX Outlet / Pump Suction	25	7.7	264	0.10
2	Pump Discharge / LTR HP Inlet	49	25.2	291	0.10
3a	LTR HP Outlet / Aux Heater Inlet	301	25.1	719	0.10
3b	Aux Heater Outlet / HTR HP Inlet	300	25.0	718	0.10
4	HTR HP Outlet / Orifice Inlet	680	24.5	1196	0.10
5	Orifice Outlet / PHX Inlet	674	8.1	1196	0.10
6	PHX Outlet / HTR LP Inlet	800	8.0	1354	0.10
7	HTR LP Outlet / LTR LP Inlet	408	7.8	876	0.10
8	LTR LP Outlet / CHX Inlet	53	7.8	447	0.10



Test Planning and Instrumentation

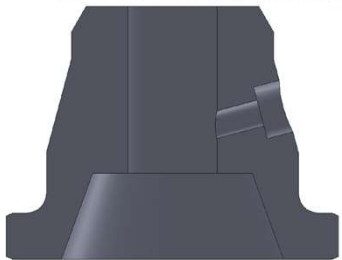
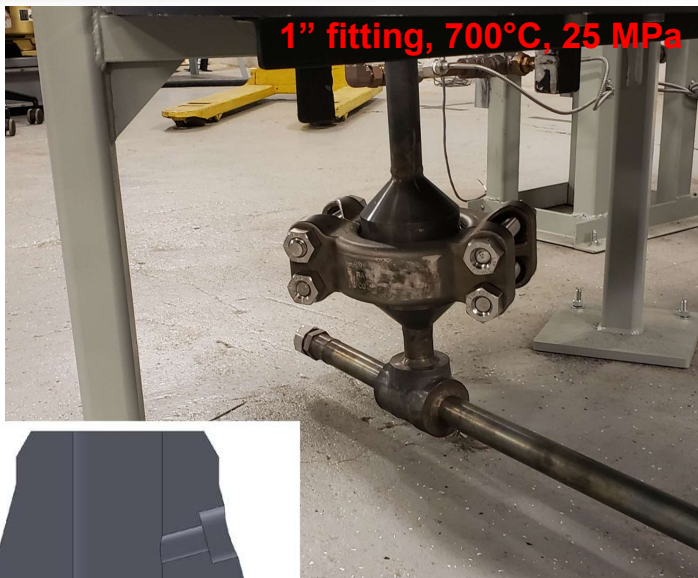
Test Planning

- Performance testing – steady state evaluation of UA using inlet/outlet conditions and CO₂ flow rate
- Cyclic testing – define goals of cyclic test
→ min/max dT/dt, cycles, duration
- Baseline rules for testing need to be defined...length of test, what is steady state, how uncertainty is accounted for.
 - ASME Performance Test Codes as guide (ASME PTC 12.5)



- Instrumentation
 - Pressure: Rosemount 3051 ($\pm 0.04\%$ of span, ~ 0.1 bar)
 - Temperature: Type R special limit TC's (\pm greater of 0.6°C or 0.1% of reading)
 - Flow: Micro Motion CMF Coriolis mass flow meter ($\pm 0.25\%$ of reading)

Fittings / Tie Points



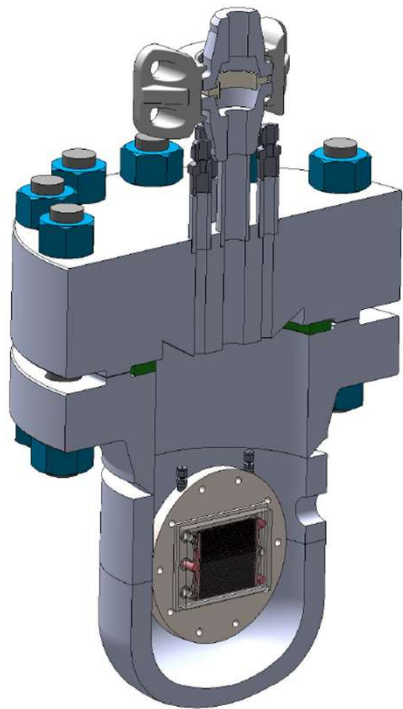
Interface option 1 – Grayloc hub

- BW, 2 GR11, SA182-F316 / F316H OR SA479-316 / 316H
- Can insert instrumentation directly through hubs (sketch)
- Echogen has INCONEL 740H tubing (1.25" OD x 0.156" wall) available
- Alternate tube interface diameters possible
- Heat losses may be an issue – heat transfer analysis in process

Interface option 2 – Direct weld

- Directly weld heat exchanger into facility tubing (1.25" OD x 0.156" w) on site
- Will need to clear dissimilar metal weld process with Special Metals (currently have 316 and 625 processes)
- Instrumentation penetrations will need to be considered individually

Ceramic heat exchanger interface example



- Pressure containment and fluid interfaces with non-metallic heat exchangers require extra design effort
- Example: MST CAMANCHE heat exchanger

