U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE

Concentrating Solar-thermal Power and Welding/PWHT for High Nickel Alloys

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Evaluation of Welding Issues in High Nickel and Stainless Steel

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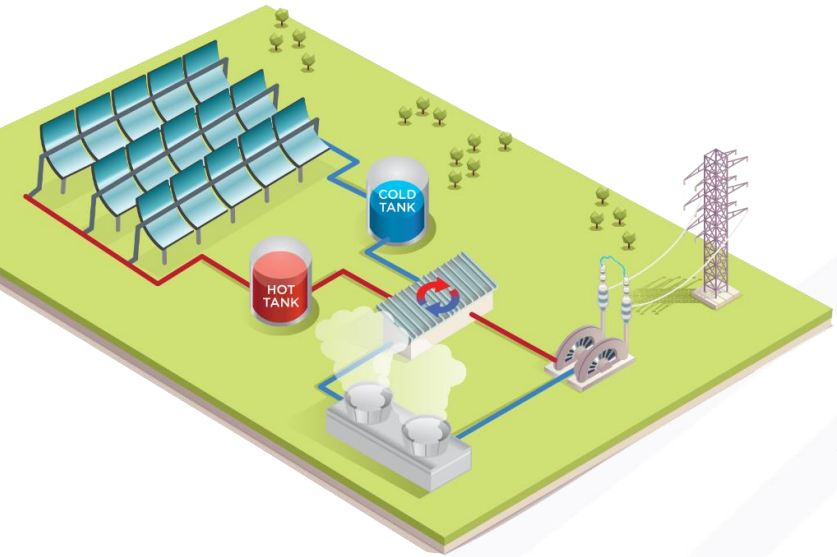
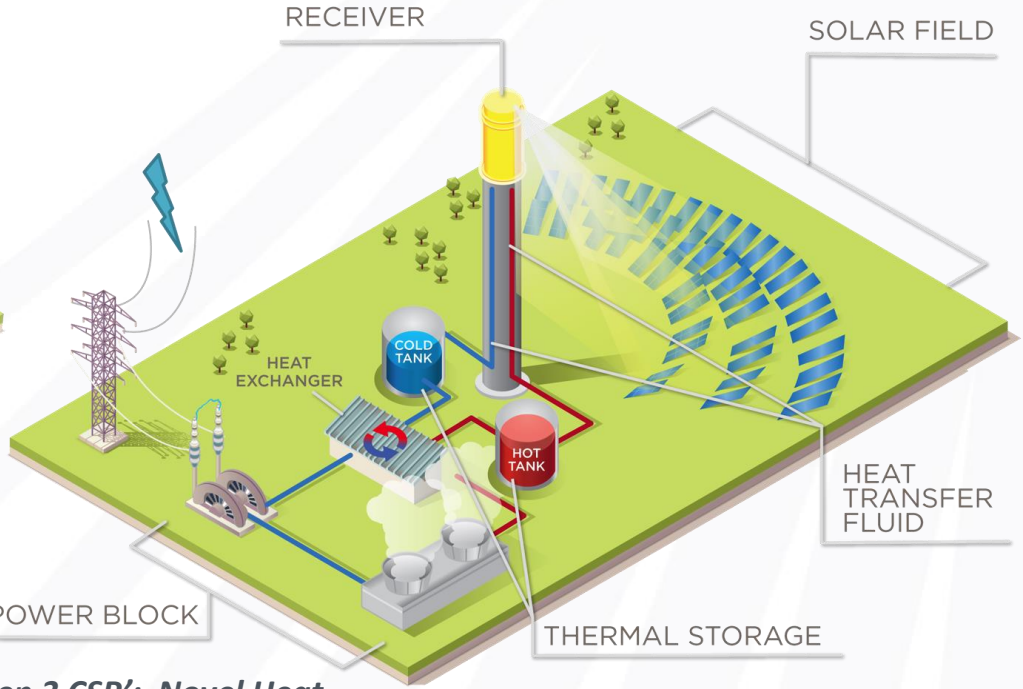
CSP with Storage is Solar Energy On-Demand





Oil-Based Troughs with steam rankine cycle (~400 °C) → ***Molten Salt Towers with steam rankine cycle (~565 °C)*** → ***'Gen 3 CSP': Novel Heat Transfer Media with advanced power cycle (>700 °C) @ 5¢/kWh***

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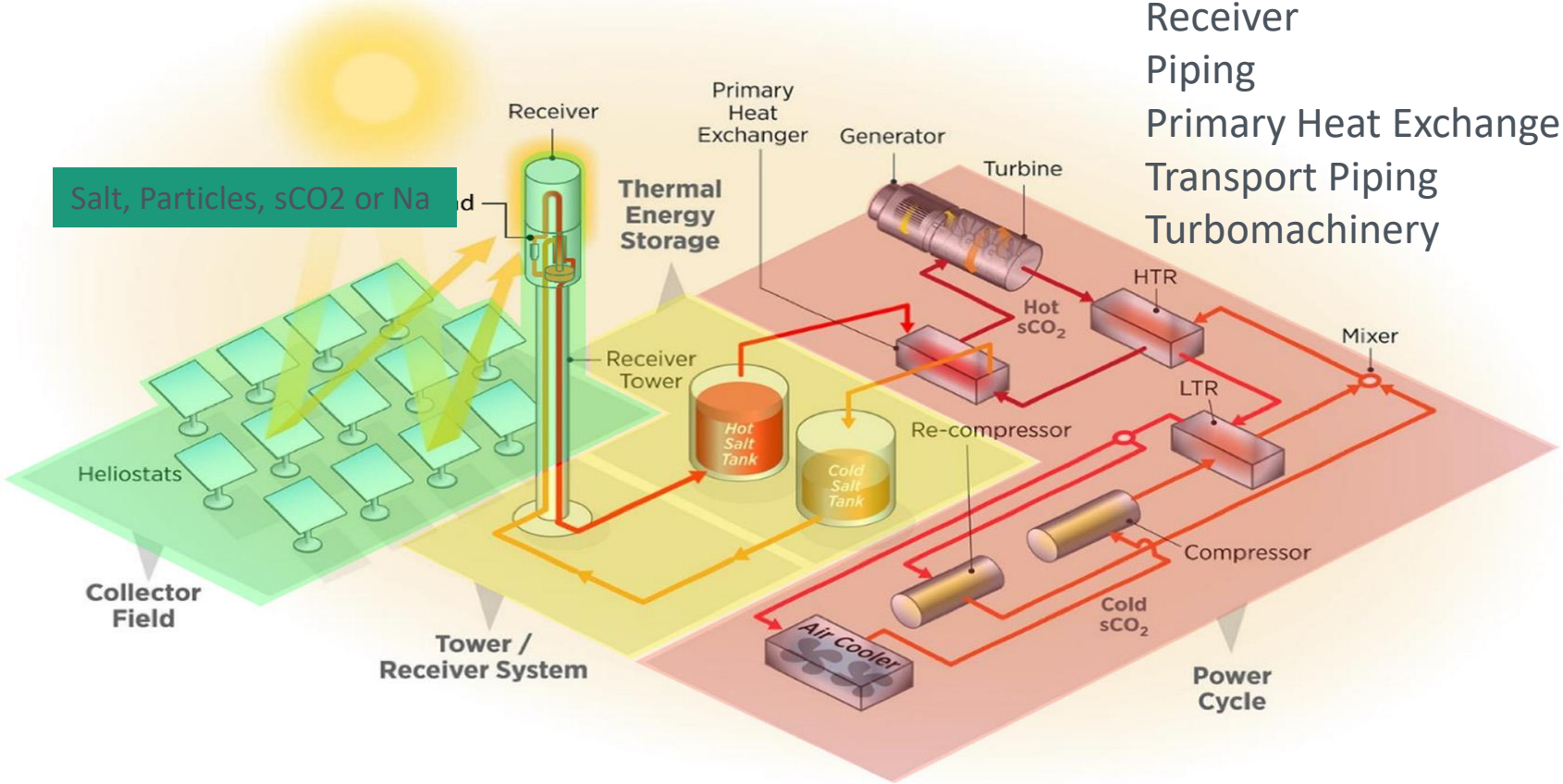
CSP Welding Needs for GEN3 Applications

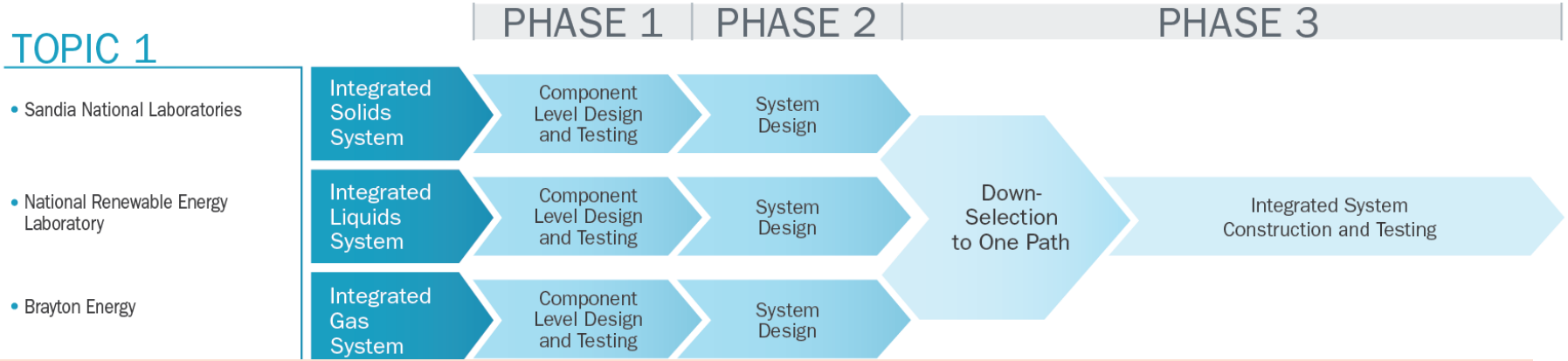
High Nickel Alloys in:

- Receiver
- Piping
- Primary Heat Exchanger
- Transport Piping
- Turbomachinery



Gen3 CSP: Raising the Temperature of Solar Thermal Systems

GEN3 CSP FUNDING PROGRAM	
Thermal Pathway	**Primary Challenges**
Liquids	Reliable corrosion management with advanced molten salts
Solids	Efficiency and reliability of heat and mass transfer of particles
Gas	Integrating low-density gases with cost-effective thermal energy storage



- Phase 2 ended in January 2021 – down-selection applications are currently undergoing external merit review and clarification interviews
- $25M has been carried over to award to down-selected pathway to build MW-scale test facility

Welding/PWHT Requirements for CSP Power Plants

GEN 2 Welding and PWHT

- Hot Nitrate Salt Tanks
  - SS347 H to 565°C
- Receiver
  - H230 to 565°C
- Superheater
  - SS316L to 565 °C

GEN3 Welding and PWHT

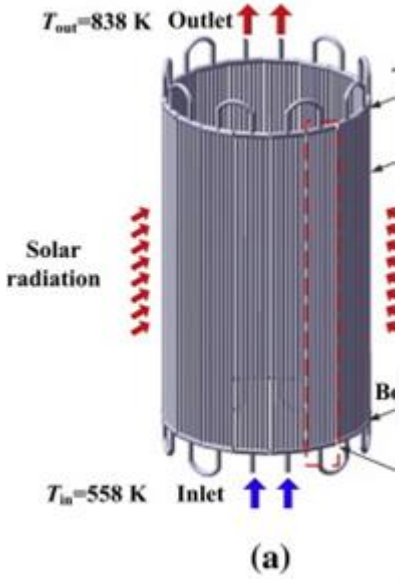
- Hot Chloride Salt Tanks
  - 740H/H282 to 750 °C
- Cold Chloride Salt Tanks
  - SS347 H to 565°C
- Piping and welds to valve body and molten salt pump
- Receiver
  - 740H to 760°C
- Primary Heat exchanger
  - 740H to 760°C

US Example of Hot Salt tank

- 110 MWe Crescent Dunes
- 140’ (42.7 m) diameter
- 40’(12.1 m) height
- Technical targets:
  - 10-hour storage
  - 2,700 MWth
  - 347H SS construction
  - 540°C hot nitrate salt
  - Type 347H stainless steel for temperatures above 538°C
  - Higher chrome alloys require post weld heat treatment

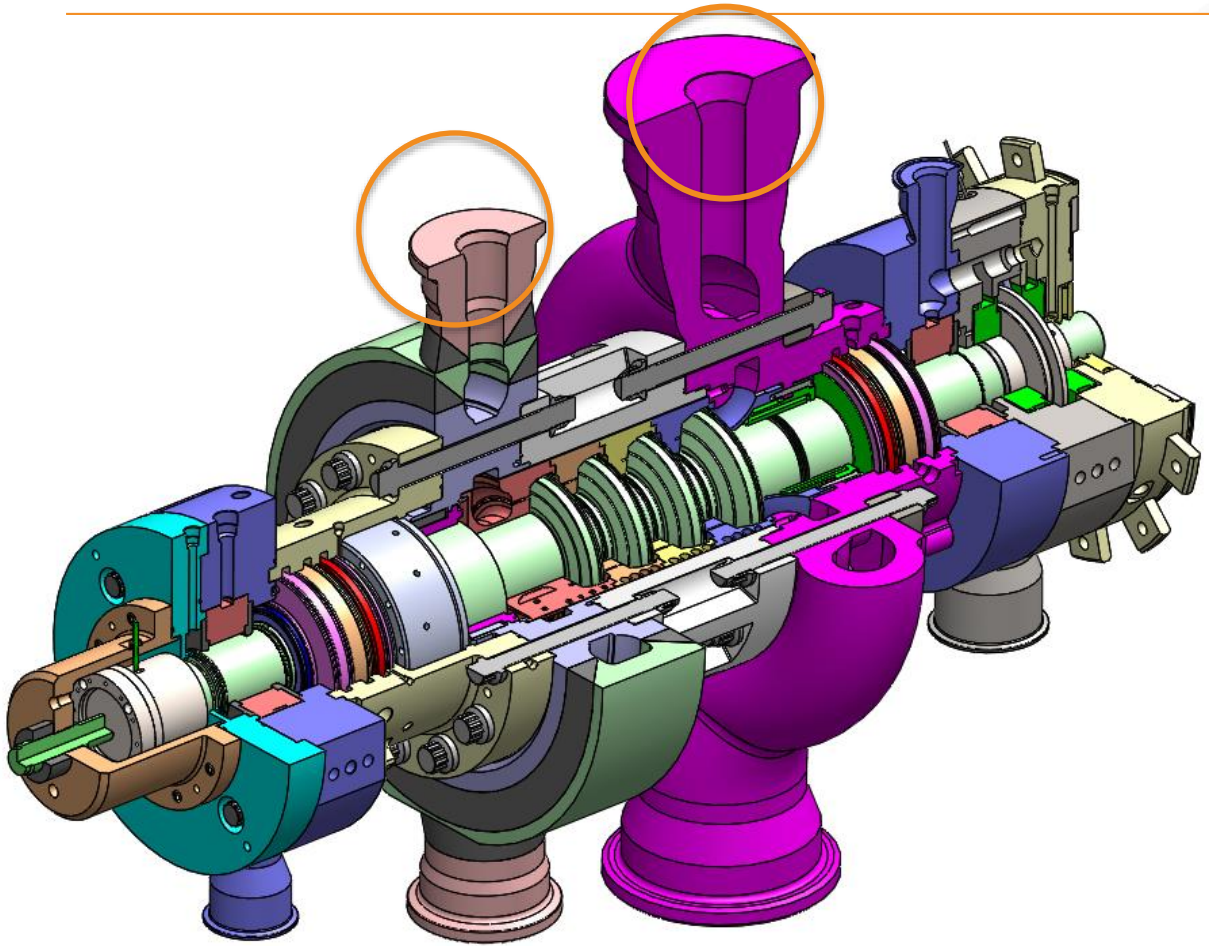
Acknowledgement to Bruce Kelly, Solar Dynamics for permission

Receiver: welding and PWHT needs



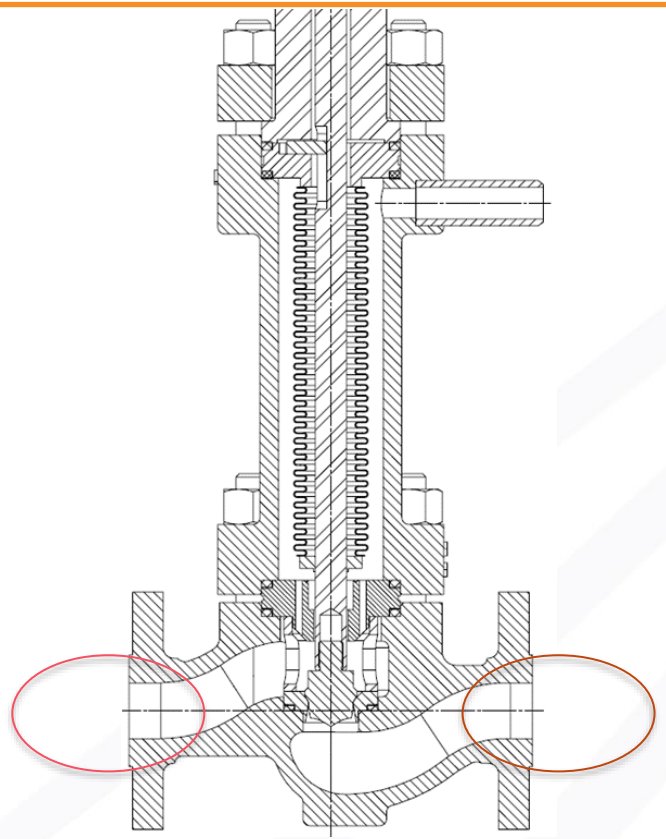
- Molten salt Receiver Design and Welding/PWHT
  - Panels with tubes for multiple pass of molten salt
  - Salt passes 8X2 times up and down the influx
  - Tubes welded to headers at the top and bottom
  - Headers welded to a pair of inlet/outlet piping
  - Haynes 230 used for current generation of receivers
  - Current generation of receivers limited by Nitrate salt to 565°C
  - Next generation of receivers use 740H for chloride salt
  - 750°C target

sCO_2 Expander Casing Welding to Pipe



- sCO_2 expander casing
  - 715°C 260 bar inlet T/P
  - H-282 Casing material
  - Hot pipe 740H or H282
  - Cold Pipe Stainless Steel
  - Welding to Pipe at Inlet and Outlet
  - Dissimilar metal welding and PWHT
  - If casing is made of more than one section, will need weld and PWHT

Welding Valves to Pipe



- Welding Valves and Piping
  - CSP power tower between 200-260 m in height
  - Hot pipe from receiver outlet to hot salt tank up to 300 m long
  - Hot pipe from the hot salt tank to Hot salt pump, and from the pump to primary heat exchanger
  - Salt 715 C/20 bar; sCO2 temperature 715 C/260 bar
  - Pipe to pump
  - Pipe to pipe
  - Pipe to elbow/bend

CSP and Welding/PWHT: A Summary

- Welding and PWHT Consideration for Stainless Steel (347H) and High Nickel Alloys
- Welding of high Ni alloys for both GEN-2 and GEN-3
- GEN-2 at Moderate Temperatures; PWHT considerations for hot salt tank
- GEN-3 at 720 C sCO2 inlet temperatures: Welding and PWHT important for CSP industry for these location:
  - Hot Salt Tank
  - Cold Salt tank
  - Receiver
  - Piping
  - Heat exchanger (headers)
  - Turbine welding to Piping
  - Valve and Pump Welding to Piping

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Questions?

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