

Development of a High-Temperature, Long-Shafted, Molten-Salt Pump for Power Tower Applications

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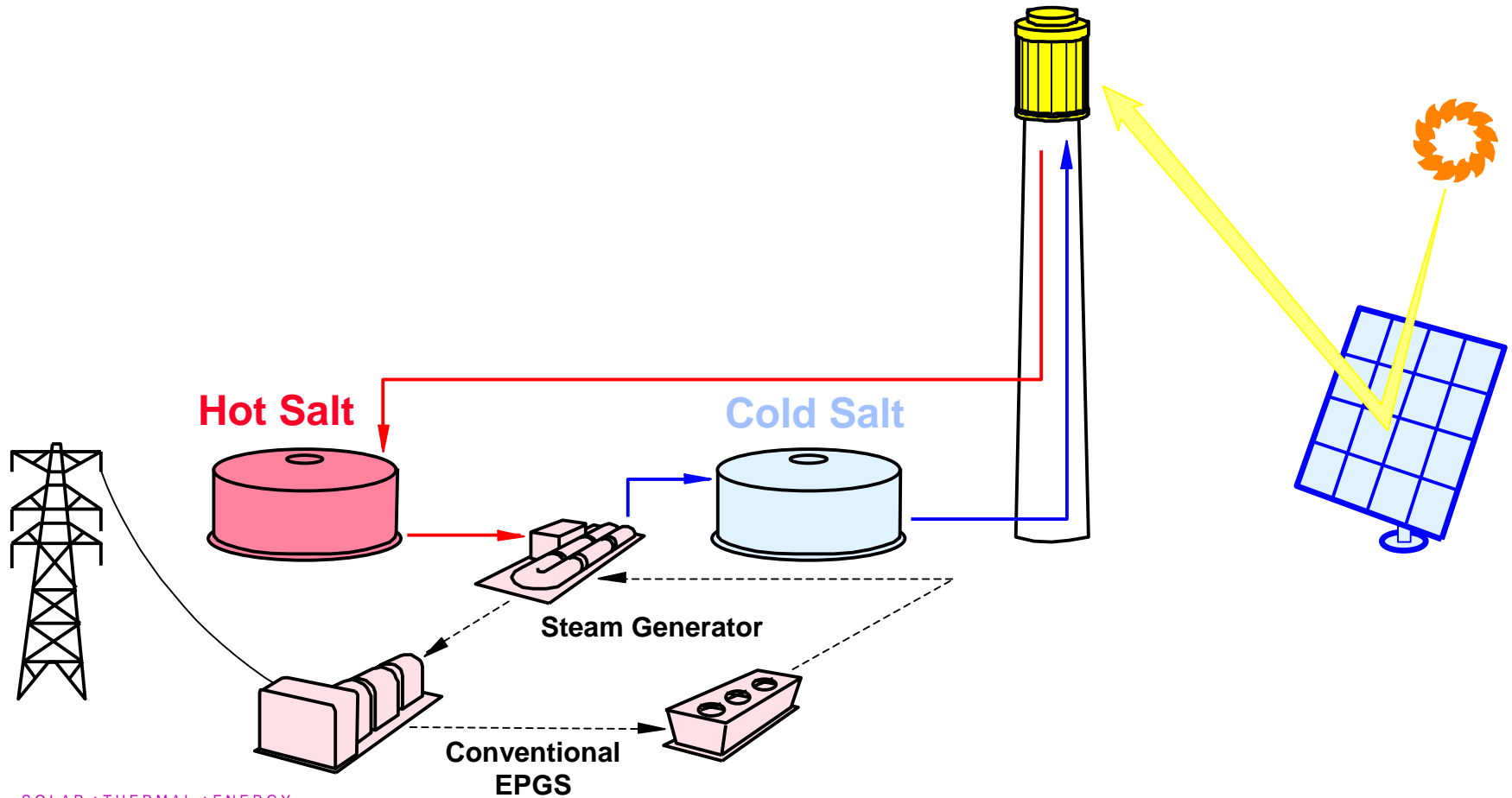
Sandia National Laboratories

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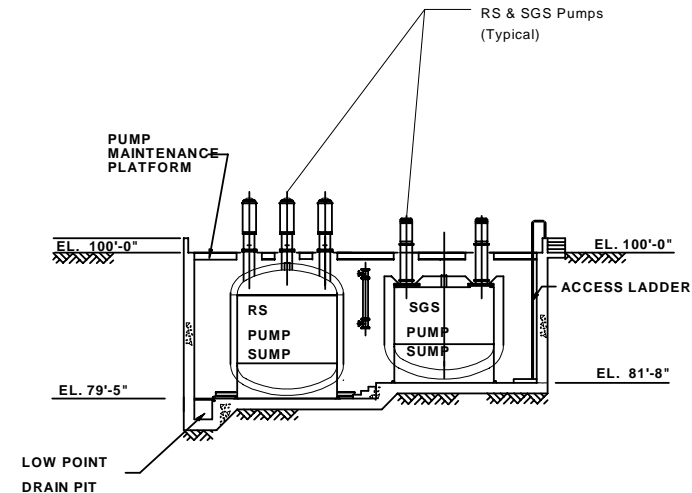
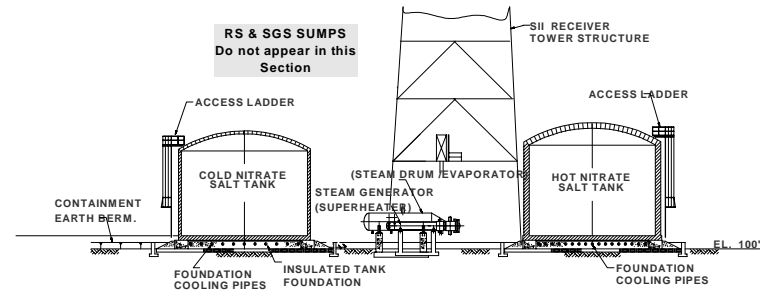
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Molten Salt Power Tower Technology



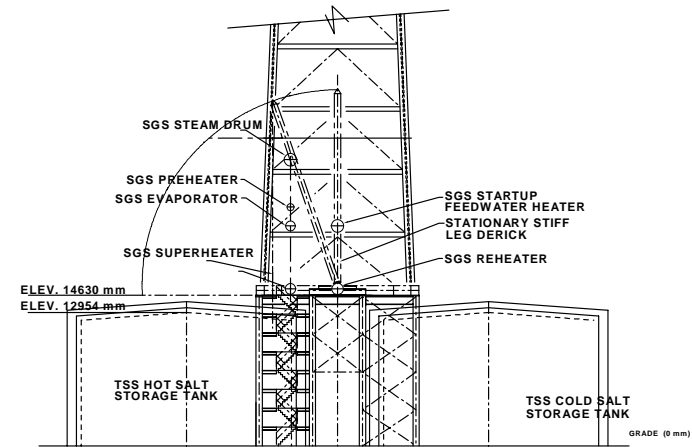
Limitations of Pumps Used at Solar Two

- Hot side used cantilever pumps because no suitable bearing materials had been proven for use in “hot” salt service (e.g., 570 deg C)
- Because the hot pumps were a cantilever design, their length was limited to 3 m.
- The short length precluded mounting the pump directly in the storage tank, thus requiring separate pump sumps.
- Cold pumps used salt lubricated bearings



Pumps Mounted in the Tanks Would Greatly Simplify the Molten-Salt System

- Eliminate the pump sumps, control and shut off valves, level instrumentation and associated heaters
- Reduce heat loss
- Allow the steam generator system to drain directly into the tanks
- Sandia National Laboratories teamed with Nagle Pumps to develop a long-shafted salt pump as part of the DOE Concentrating Solar Power Program

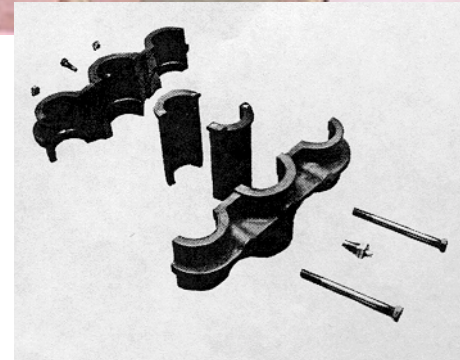
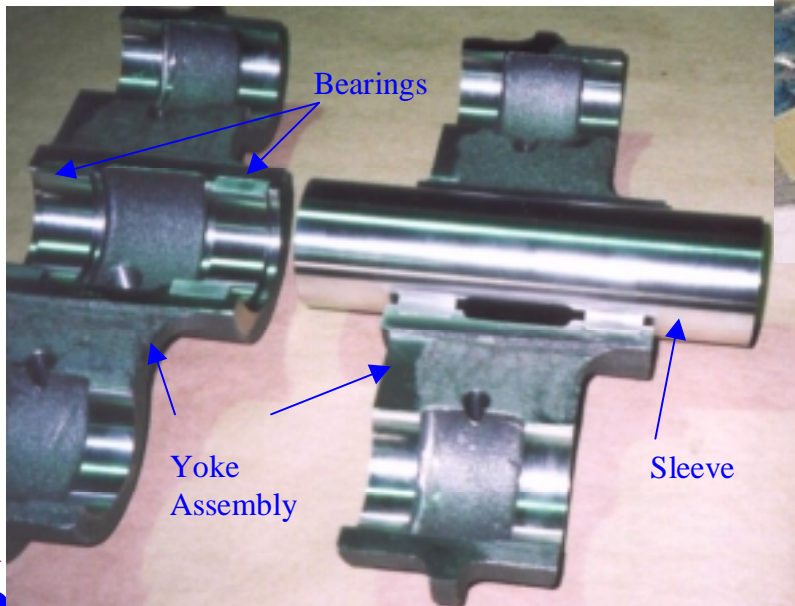


Desirable characteristics of bearing materials:

- Non-galling
- Low corrosion
- Easily machined
- Low cost

Description of Test Pump

- 7.6 m long
- Salt lubricated bearings
- Modified Nagle YWS design
- 5 yoke assembly
- Several bearing/sleeve materials tested at once



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Bearing / Sleeve Materials Tested

Yoke Number	Journal Sleeve Material (Mounted to Shaft)	Bearing Material (Mounted to Yoke Assembly)
1 (Top)	NPI 420 Stainless	60-45-10 Ductile Iron (Full Length)
2	Stellite 6B	Ni-Resist Type 1 (Upper) 60-45-10 Ductile Iron (Lower)
3	NPI 420 Stainless	Gray Cast Iron Grade 40 (Upper) Gray Cast Iron Grade 40 (Lower)
4	Tribaloy T-900	Ni-Resist Type 1 (Upper) Ni-Resist Type 1 (Lower)
5 (Bottom)	Stellite 6B	Gray Cast Iron Grade 40 (Full Length)

- Selected for their non-galling characteristics and compatibility with nitrate salts

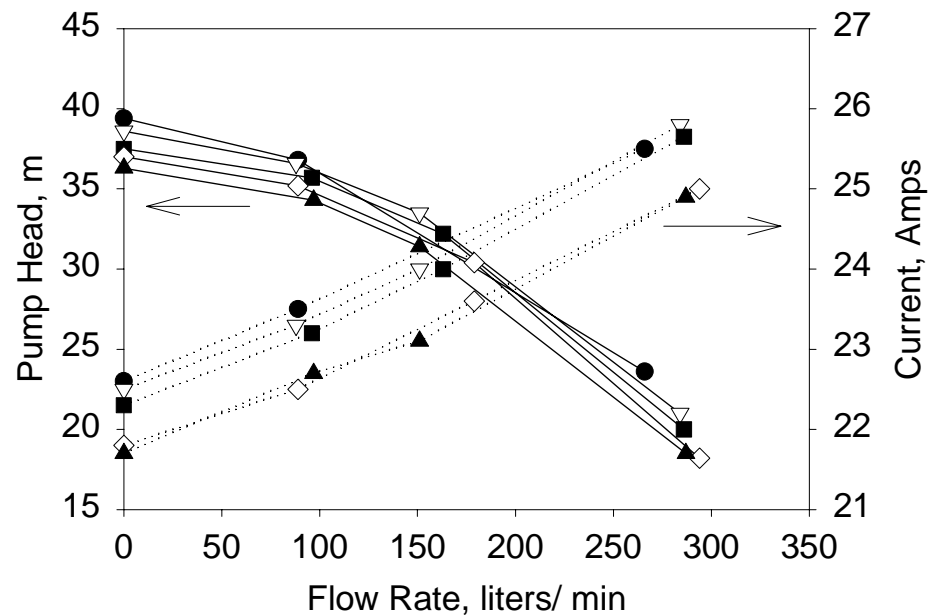
Tests Conducted

- Characterize the pump, simulate operating modes and operate pump for extended time periods
- Pump head versus motor current as a function of flow rate (at 345, 400, 455, 510 and 565 deg C)
- Endurance test: 7 hours on, 1 hour off continuously around the clock at full flow at 565 deg C.



Test Results

- Pump curves matched design specifications
- Pump operated for over 5000 hours
- Measurements before and after showed there were no vibration problems
- After all testing was completed, the pump was disassembled, bearing and sleeve were inspected and dimensions were measured
- All bearings and sleeves were reusable, only requiring polishing of the surfaces



Test Results (continued)

- Best combination was Stellite 6B sleeve with a gray cast-iron bearing.
- In place of Stellite 6B, lower cost NPI 420 stainless steel could be used.
- Tribaloy T-900 showed heavy pitting on the bearing surface and is unsuitable
- Ductile iron had heavy scale buildup and flaking and is not recommended as a bearing material.
- Ni-Resist faired well as a bearing material but is more expensive than gray cast iron



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Implications of the Results

- Pump lengths of 15 m can be commercially built for mounting in the storage tanks in a molten salt power tower.
- Heat loss will be reduced by 10 to 20% over the previous design because the pump sumps, valves, and interconnecting piping will be eliminated. The capital cost of the storage system will be reduced as well.
- This pump design can also be used in parabolic trough plants that use molten salt thermal storage.



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