SunShot
U.S. Department of Energy

CSP Program Summit 2016

Acciona Power Plant Hydrogen Mitigation Project

CRADA partners: NREL & Acciona Energy

Project Duration: 2 years

Project Budget: $1.4M, 50/50 cost share

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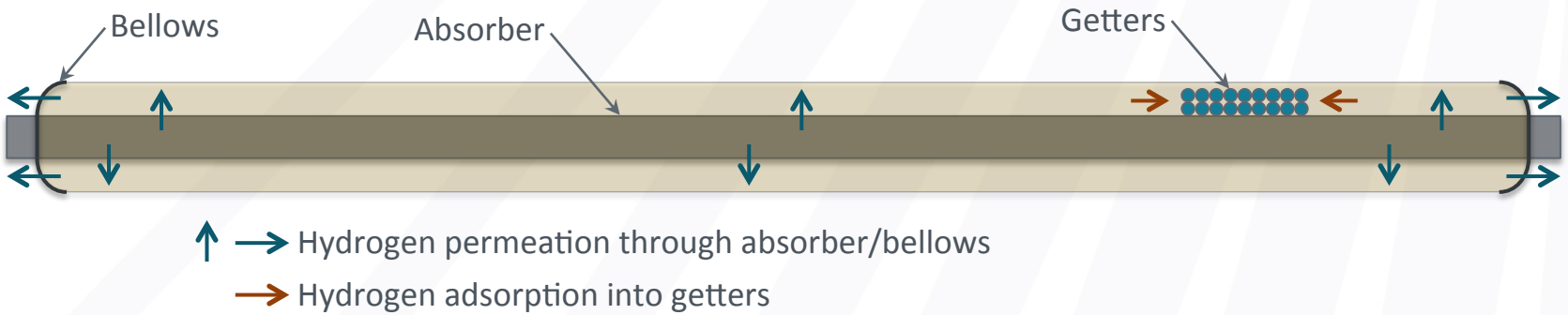
Problem to Address

Decomposition of heat transfer fluid (HTF) in parabolic trough power plants generates hydrogen that circulates in the collector field

Free-radical polymerization of biphenyl

Hydrogen permeates into receiver annuli eventually causing a significant decrease in receiver performance and power plant output



Value Proposition

- Process removes hydrogen from the power plant expansion tanks to control hydrogen levels in the circulating heat transfer fluid
- Process has not capacity limits for removing hydrogen – getters have limited capacity and eventually saturate
- Creates opportunity to decrease receiver cost by eliminating:
  - barrier coatings
  - getters,
  - xenon capsules
- Ultimately results in increased plant performance and greater profitability

Project Objectives

Overall objective: design, implement, and evaluate a full-scale hydrogen mitigation system at Nevada Solar One (NSO)

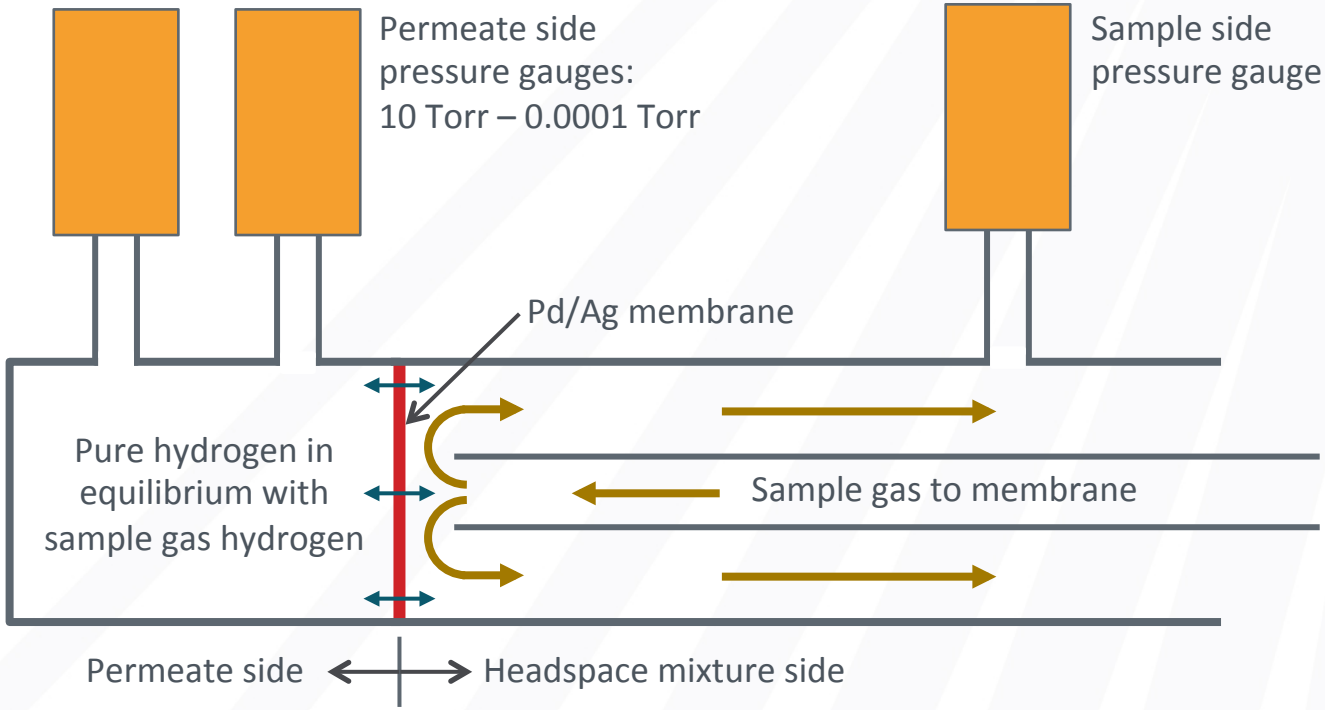
- Develop instrumentation to measure the hydrogen partial pressure in the HTF expansion tank headspace gas
- Demonstrate reverse permeation of hydrogen from in-service receivers and performance improvement
- Design and process that purges hydrogen from the NSO expansion tank and maintains HTF hydrogen to target level
- Evaluate system installed costs and estimate payback period for installed system due to increased plant performance
- Implement system at NSO (Phase 2)
- Evaluate system performance at NSO (Phase 2)

Task Structure

- Task 1.1: develop hydrogen sensor to measure expansion tank hydrogen partial pressure
- Task 1.2: track increase in performance of in-service receiver due to long-term heating
- Task 1.3: specify and design a purge system for removing hydrogen from the NSO expansion tanks
- Task 1.4: estimate installed costs and payback period for installed hydrogen purge system

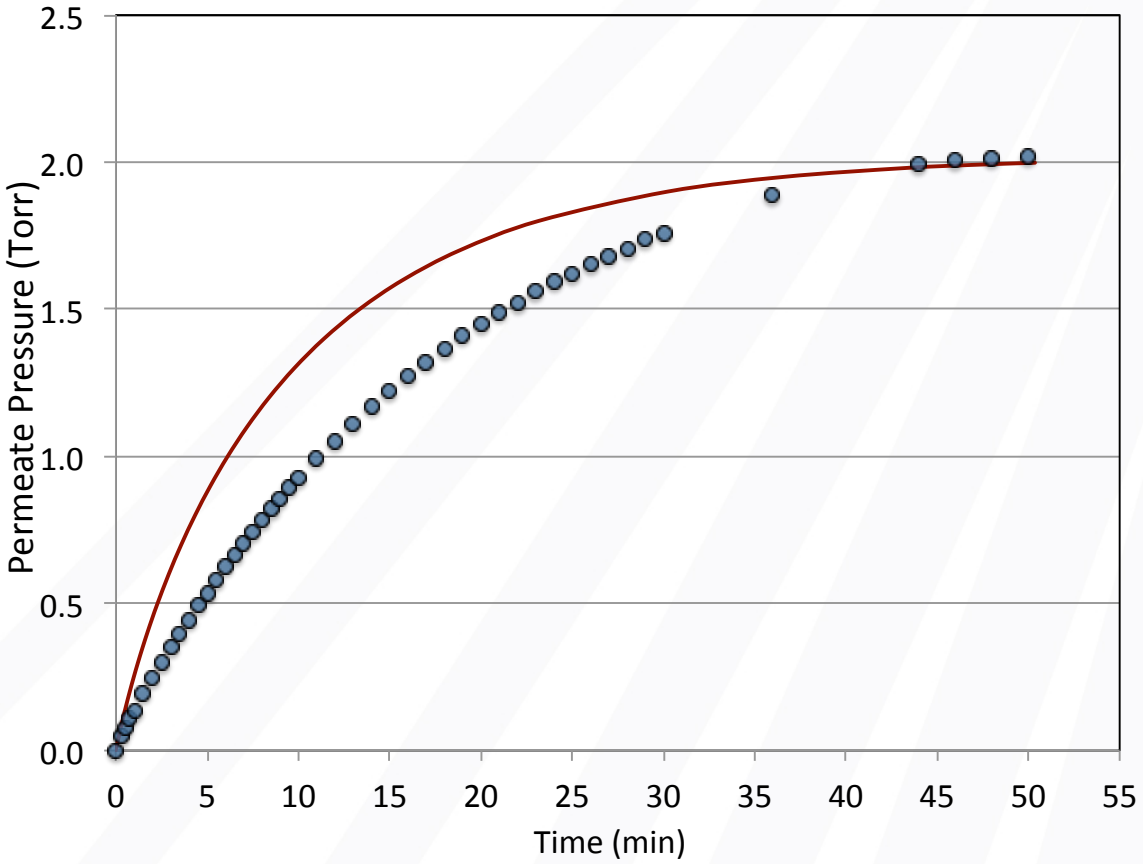
Task 1.1 Sensor Development

Establish equilibrium pressure across selective membrane equal to the hydrogen partial pressure in the gas mixture



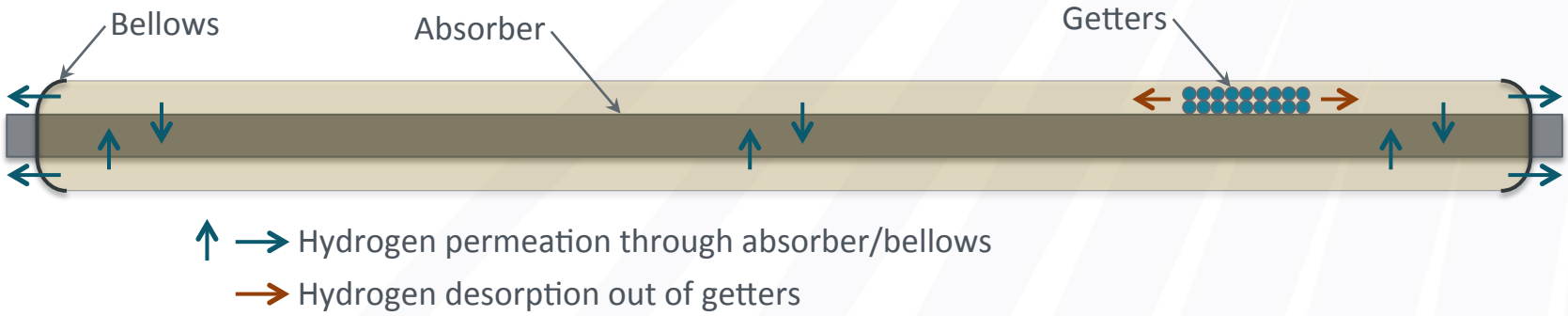
Task 1.1 Sensor Development

Hydrogen partial pressure in gas mixture determined by measuring pressure response on the permeate side of the selective membrane.



Task 1.2 Receiver Heat Loss Testing

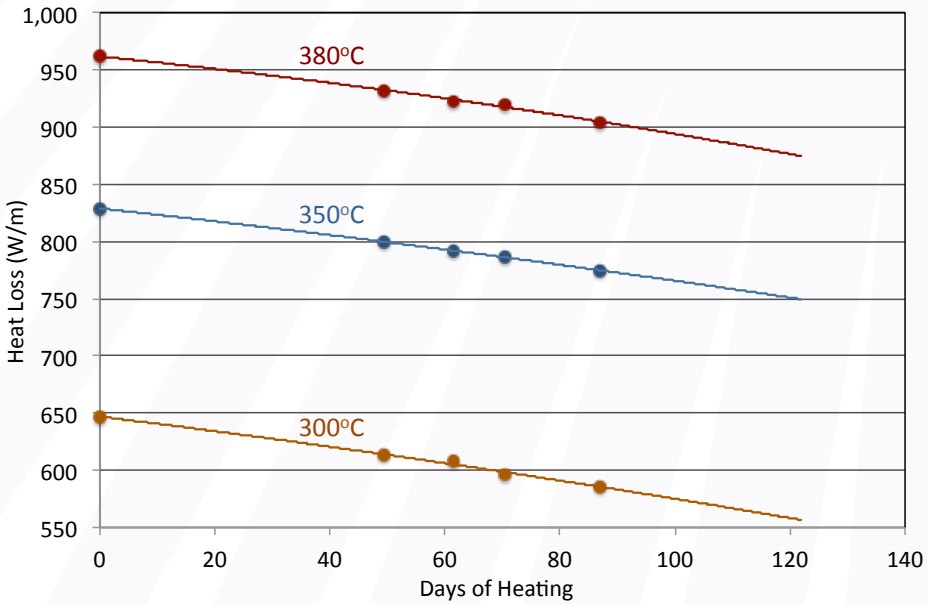
Long-term receiver heating demonstrates hydrogen reverse permeation when HTF has low dissolved hydrogen.



Task 1.2 Receiver Heat Loss Testing

- Long-term heating performed with NREL heat loss test stand
- Absorber temperature during heating is 375°C – 385°C
- Observed reduction in heat loss and improved receiver performance

Heat Loss Test Stand

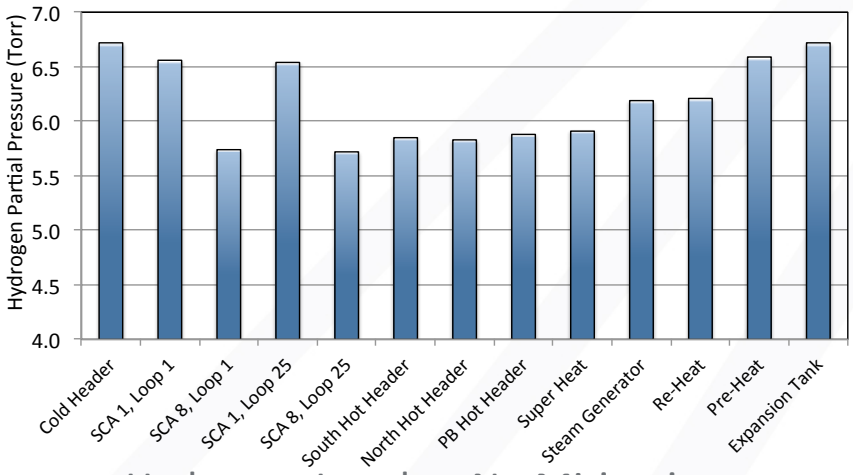


Heat Loss vs. Daily Heating

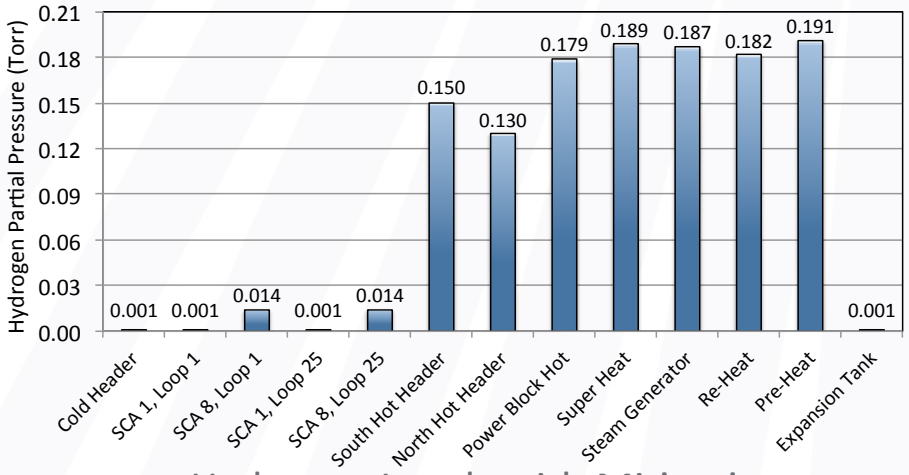
Task 1.3 Full-Plant Modeling

Full Plant Model Features

- Hydrogen material balances on all plant components – receivers, cross-over piping, hot & cold header sections, steam train components, expansion tanks, and power block piping
- Material balances for account for:
  - influx due to dissolved hydrogen in HTF flow into component
  - efflux due to dissolved hydrogen in HTF flow out of component
  - efflux due to hydrogen permeation across component walls
  - hydrogen generation due to HTF degradation



Hydrogen Levels – No Mitigation

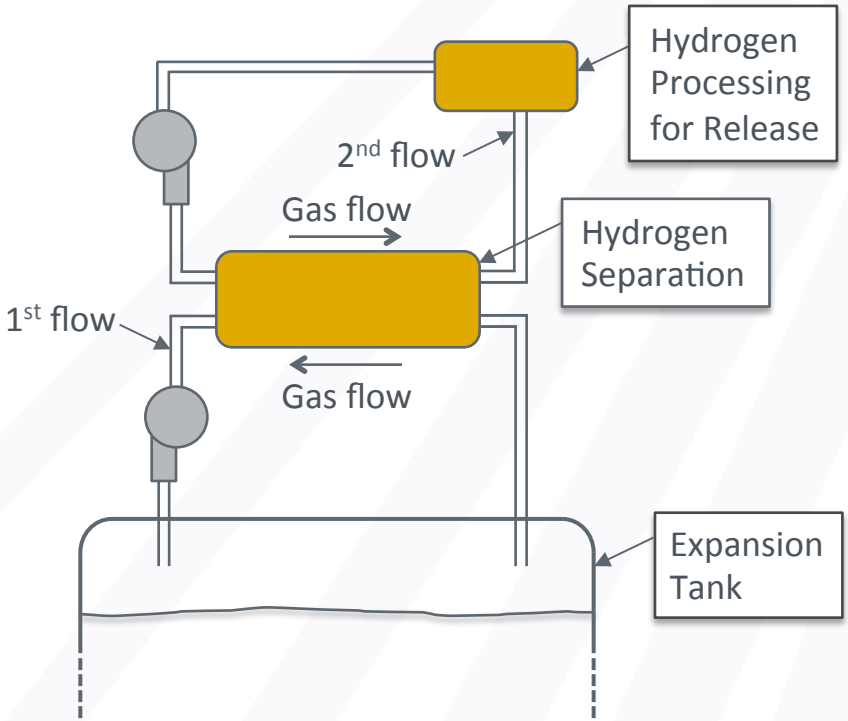


Hydrogen Levels with Mitigation

Task 1.3 Process Specification & Design

2-step process to remove hydrogen from expansion tank headspace:

- separate hydrogen from headspace gas mixture
- oxidize hydrogen to water vapor before discharging to ambient



Task 1.4 Economic Analysis

- Evaluate installed system costs and operating expenses
- Estimate payback period for installed system based on increased plant performance and electricity production
- Installed system cost for hydrogen purge system needs to pay back within 18 months

Path to Market

- Phase 2 objectives:
  - install mitigation system at Nevada Solar One
  - demonstrate operation and validate system performance
- Currently working to identify second CRADA partner to establish business unit to commercialize process