SAND2007-6788C

Sulfuric Acid Decomposition Experiments for Thermochemical Production from Nuclear Power

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*Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

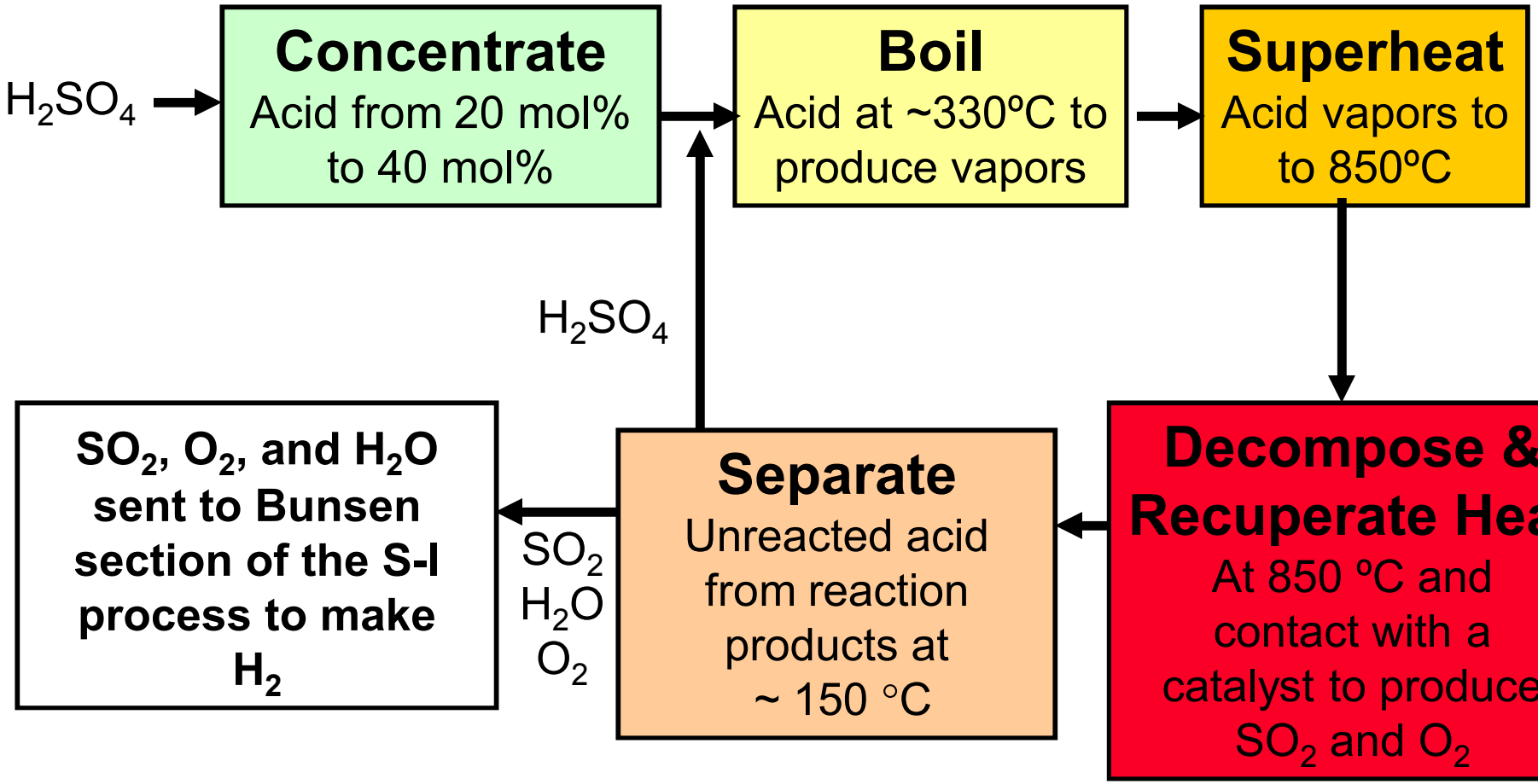
Sandia Programmatic Goals

- Develop and construct a H_2SO_4 decomposition process with a production capacity of 100 - 200 L-SO_2/hour (equivalent 100 - 200 L-H_2/hour).

- Integrate the Sandia H_2SO_4 decomposition process with the two other sections of the S-I cycle, being developed by General Atomics Corporation and the French Commissariat a l'Energy Atomique (CEA), into a demonstration scale process.

- Assembled and operated in stand-alone mode at the General Atomics Facility in San Diego in FY07. Fully integrated S-I cycle with all three reactors operating simultaneously by mid FY08.

Sulfuric Acid Section
Five Step Process



Sandia Silicon Carbide Integrated Acid Boiler/Superheater/Catalytic Decomposer

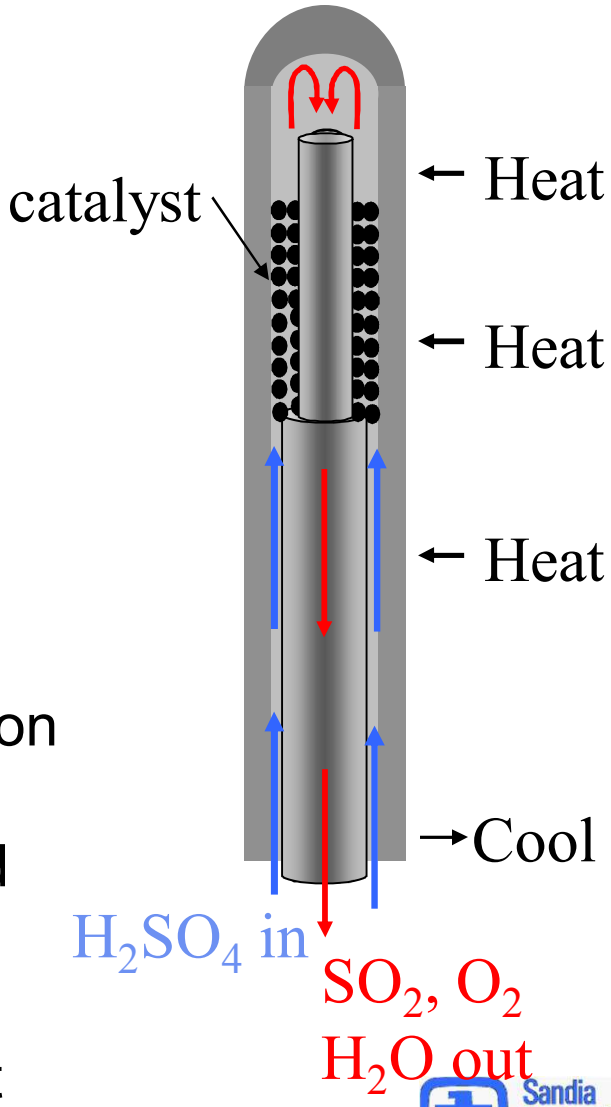
- Silicon carbide is extremely resistant to corrosion by acids

- Bayonet HX design. Heat from gaseous products traveling down the center tube is recuperated

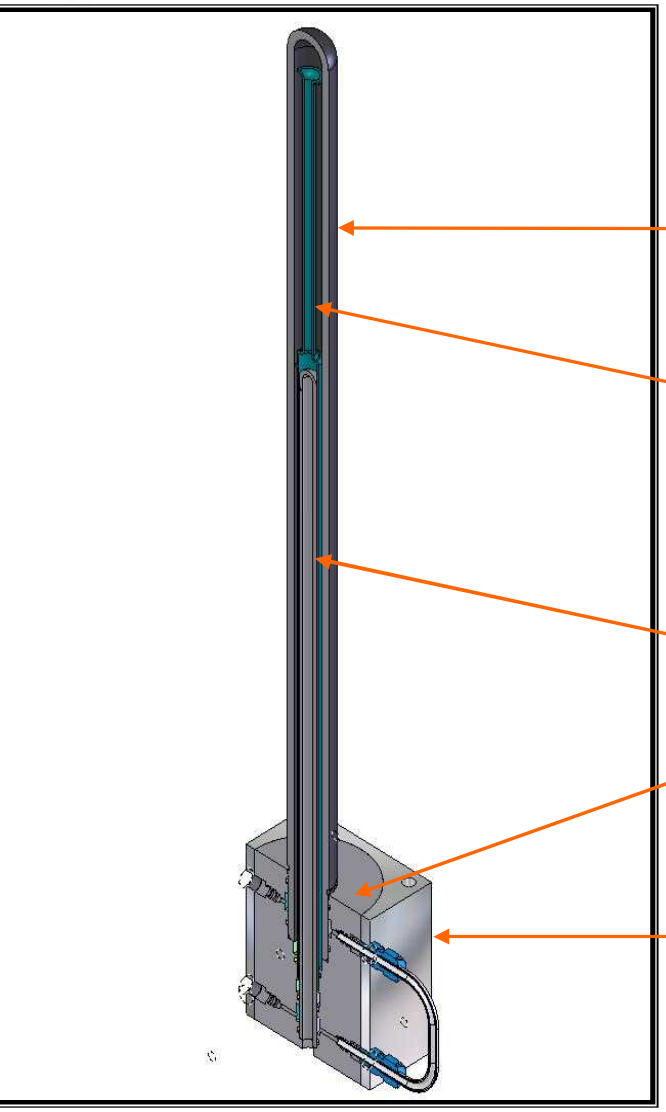
- Bayonet design eliminates all high temperature connections.

- All other equipment in the acid decomposition process operates at low temperature. This allows use of commercial glass & teflon-lined components

- Solves corrosion problem but limits catalyst access for measurements



Components of 1372 mm Bayonet



12 inch ruler (305 mm)

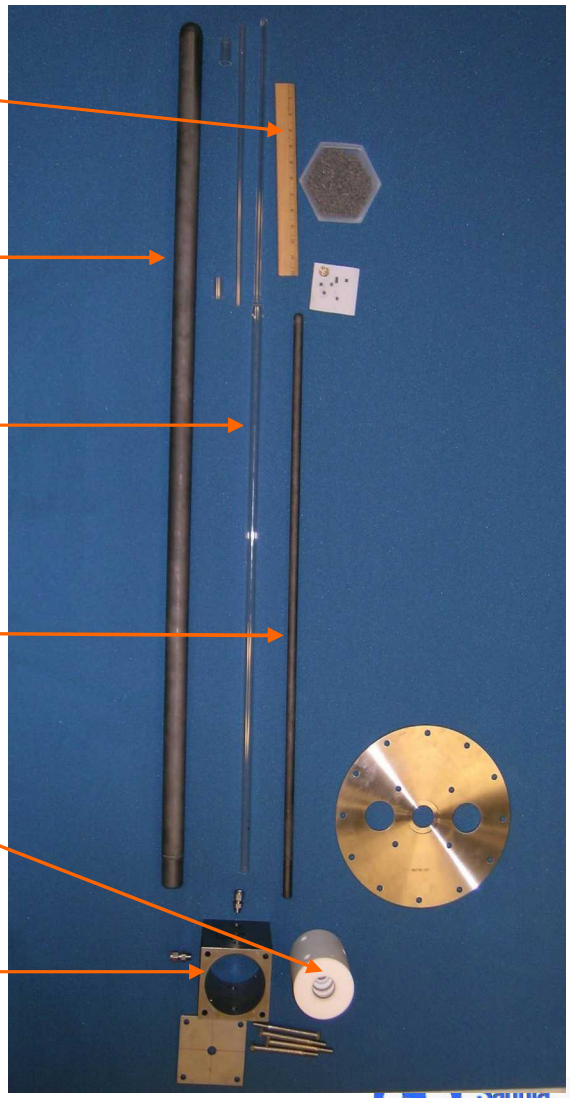
Outer SiC tube

Quartz baffle

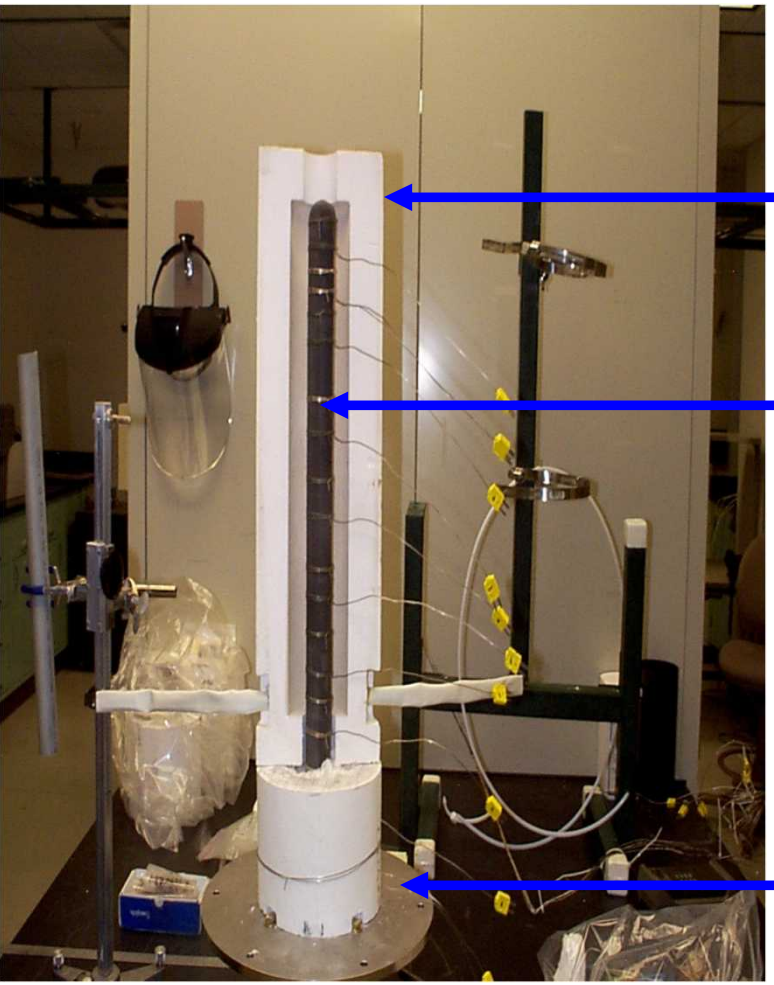
Inner SiC tube

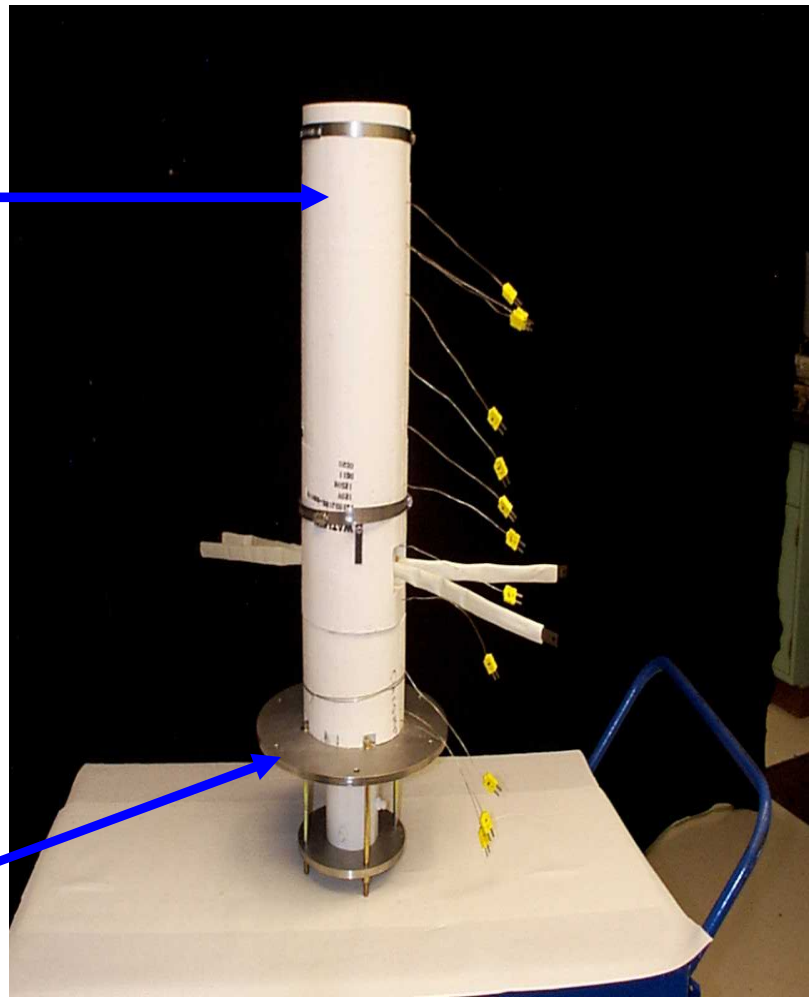
Teflon manifold

Steel block



Sandia Silicon Carbide Integrated Acid Boiler/Superheater/Catalytic Decomposer





NHI NUCLEAR HYDROGEN INITIATIVE

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Testing Phases of Bayonet

NHI
NUCLEAR HYDROGEN INITIATIVE

Shakedown and Demonstration Tests at Sandia

- **Phase 1: 686 mm (27 inch), 4 bar**
- **Phase 2: 1372 mm (54 inch), 1 bar, 20% and 40% acid**
  - **Achieved in excess of 200 liter/hr SO2 production**
  - **Incorporated multiple barriers to contain SO2 permeation**
  - **Redesigned from Teflon tubing to glass-lined steel and Teflon tubing encased in steel tubing**

Demonstration Tests at GA

- **Phase 3: 1372 mm, 1 - 3 bar, 31 mol% acid**
  - **Achieved in excess of 125 liters/hr of SO2**

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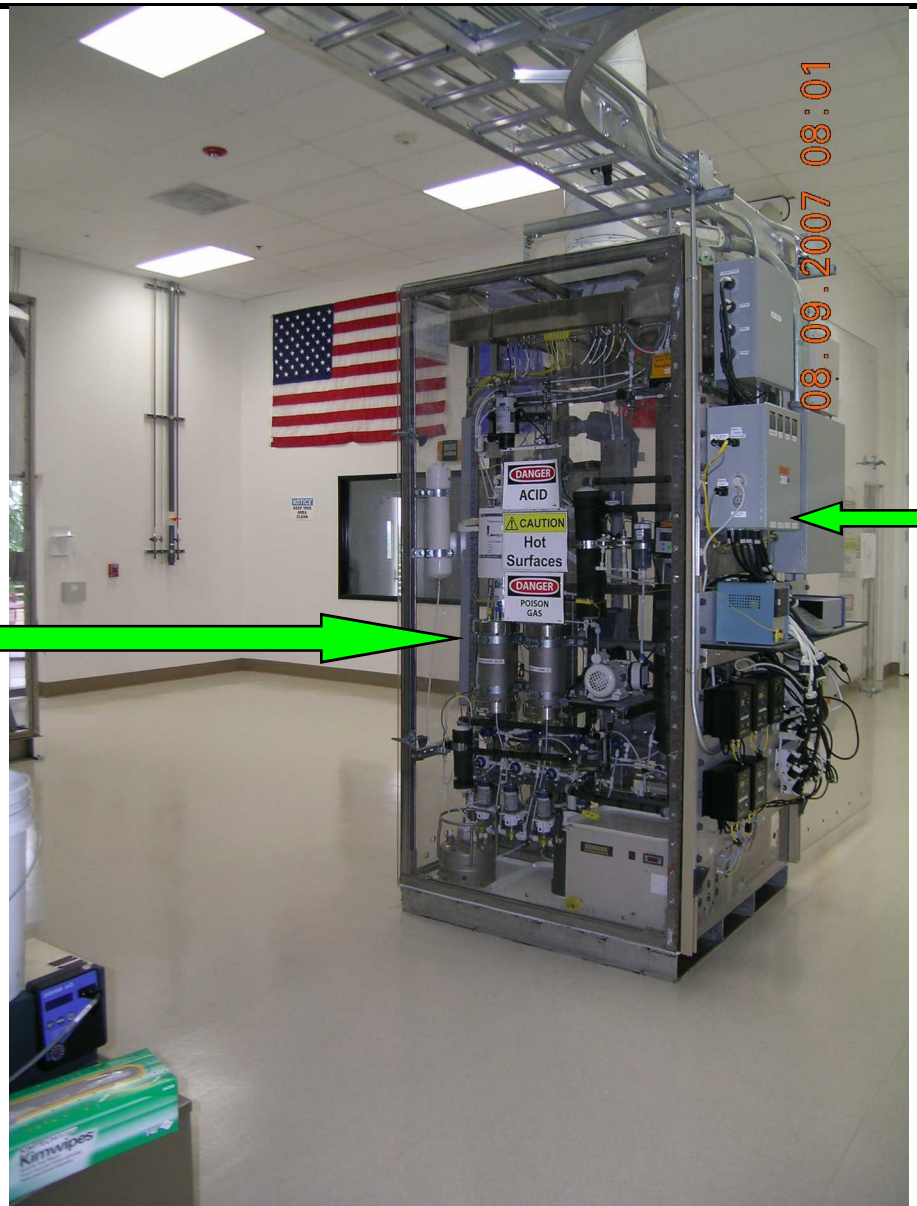
Complete H_2SO_4 Decomposition Skid

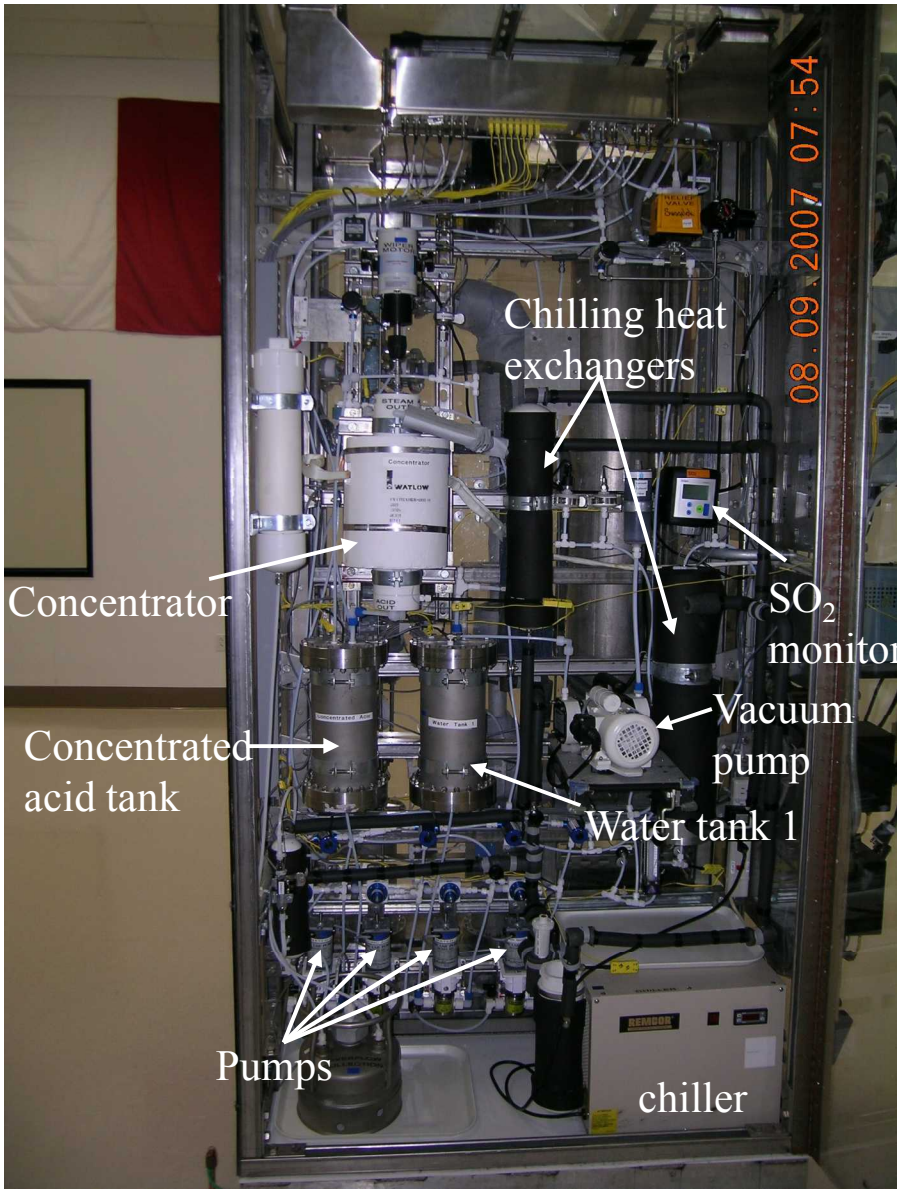


Gas-Processing Side (in back)

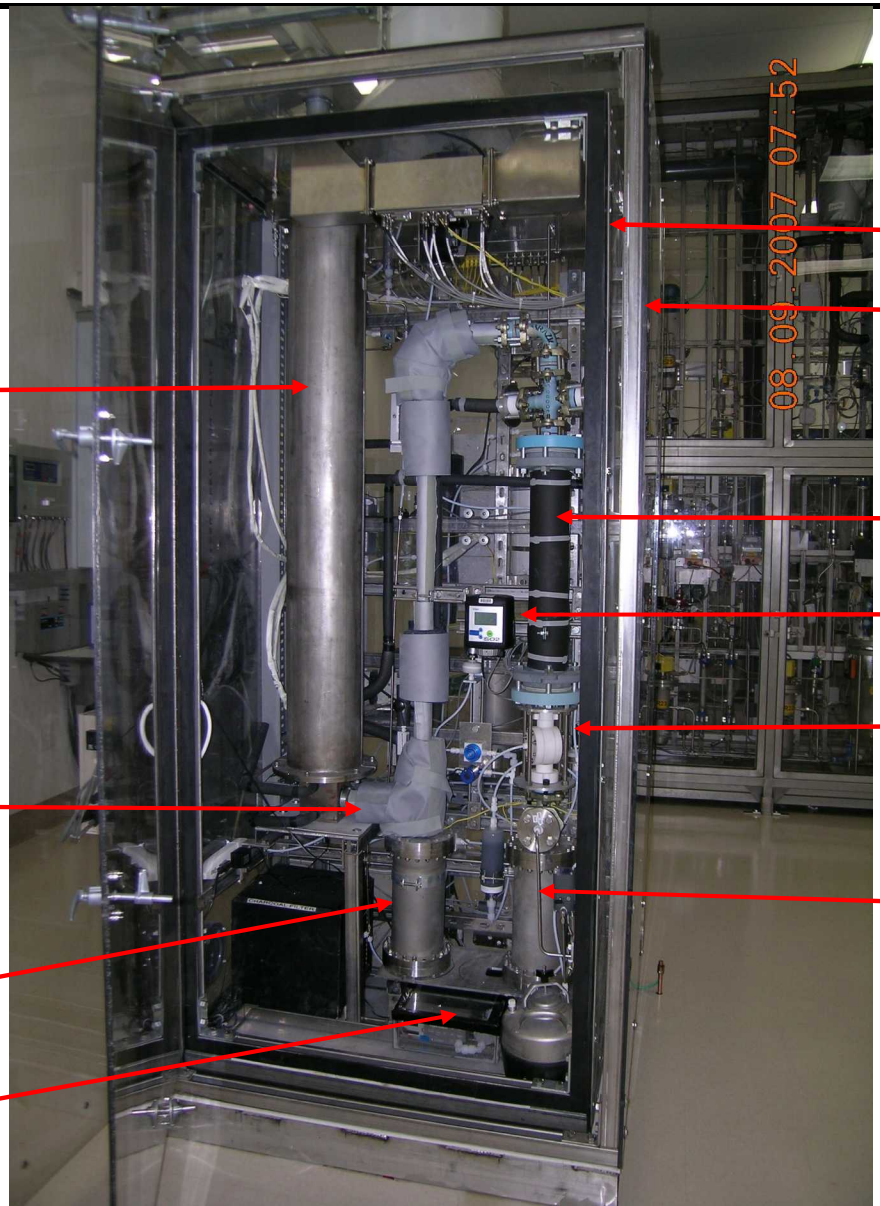
Liquid-Processing Side

Electrical Controls Panel

Liquid-Processing Side (H_2SO_4 and H_2O)



Gas-Processing Side (SO_2, O_2, and H_2O)



Catalyst-loaded bayonet with heaters enclosed by a protective steel shroud

Bayonet outlet

Acid recycle tank

Oxygen analyzer

Inner enclosure

Outer enclosure

Water condenser

SO_2 monitor

Back pressure regulator

Water Tank 2

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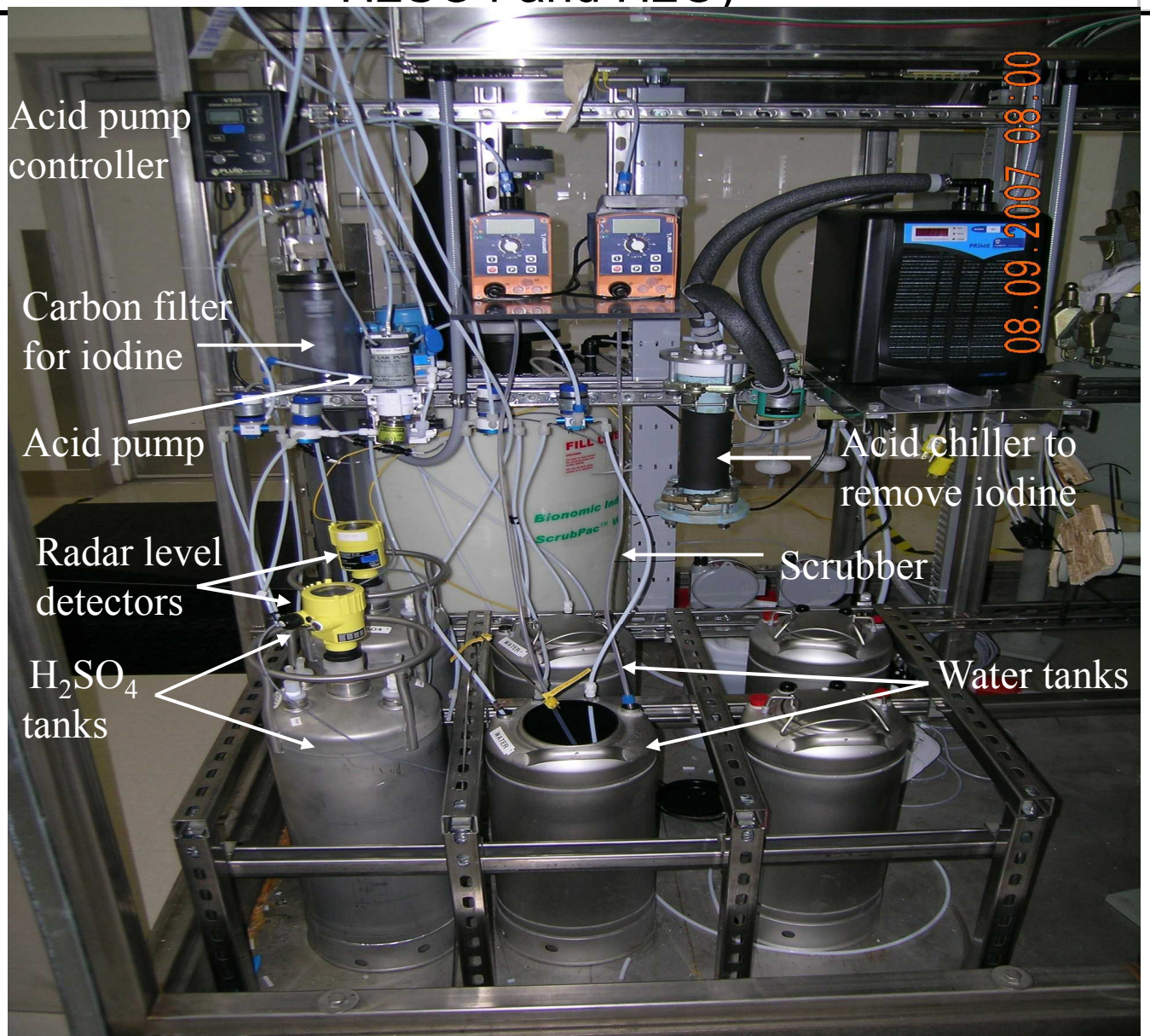
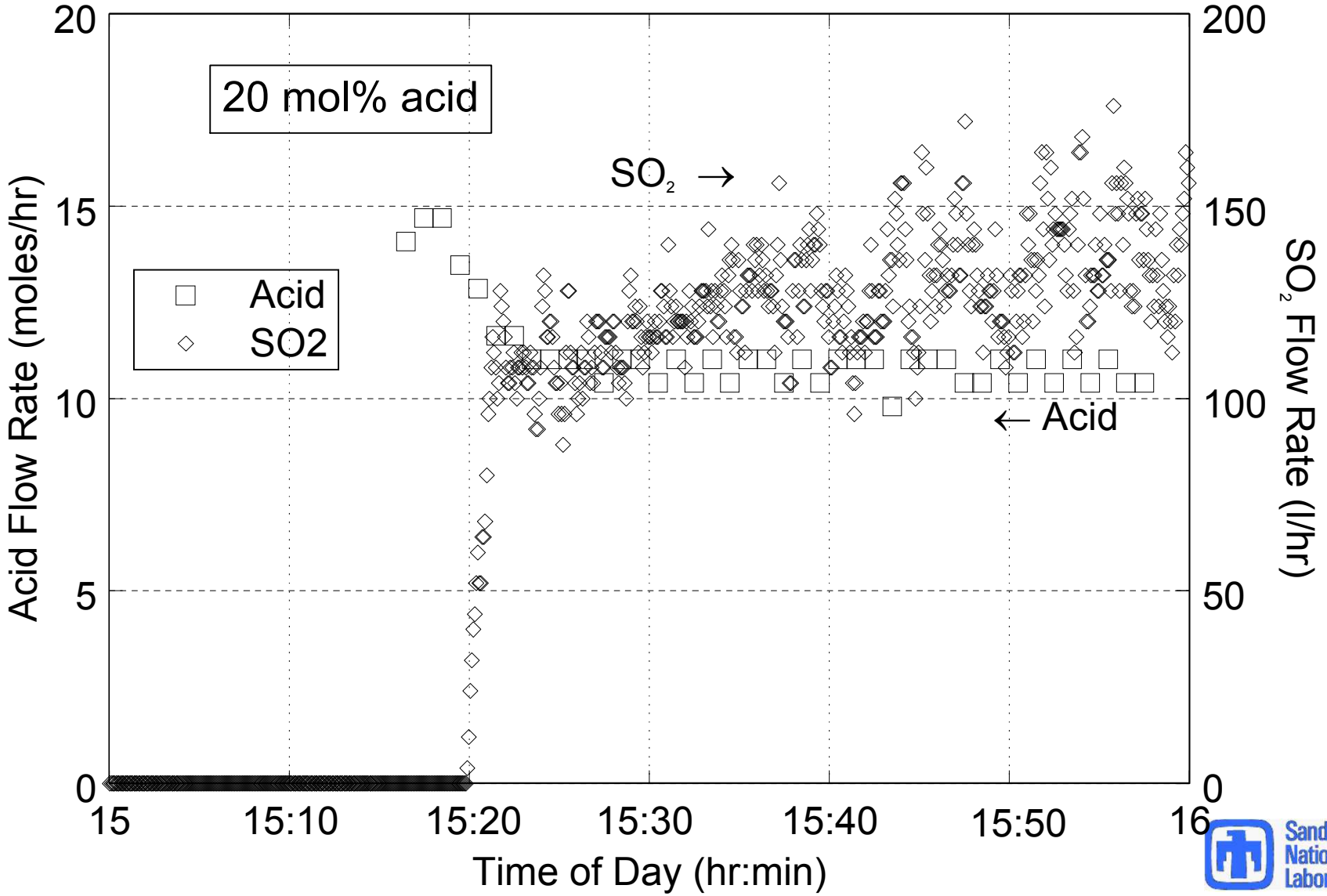
Interface Skid

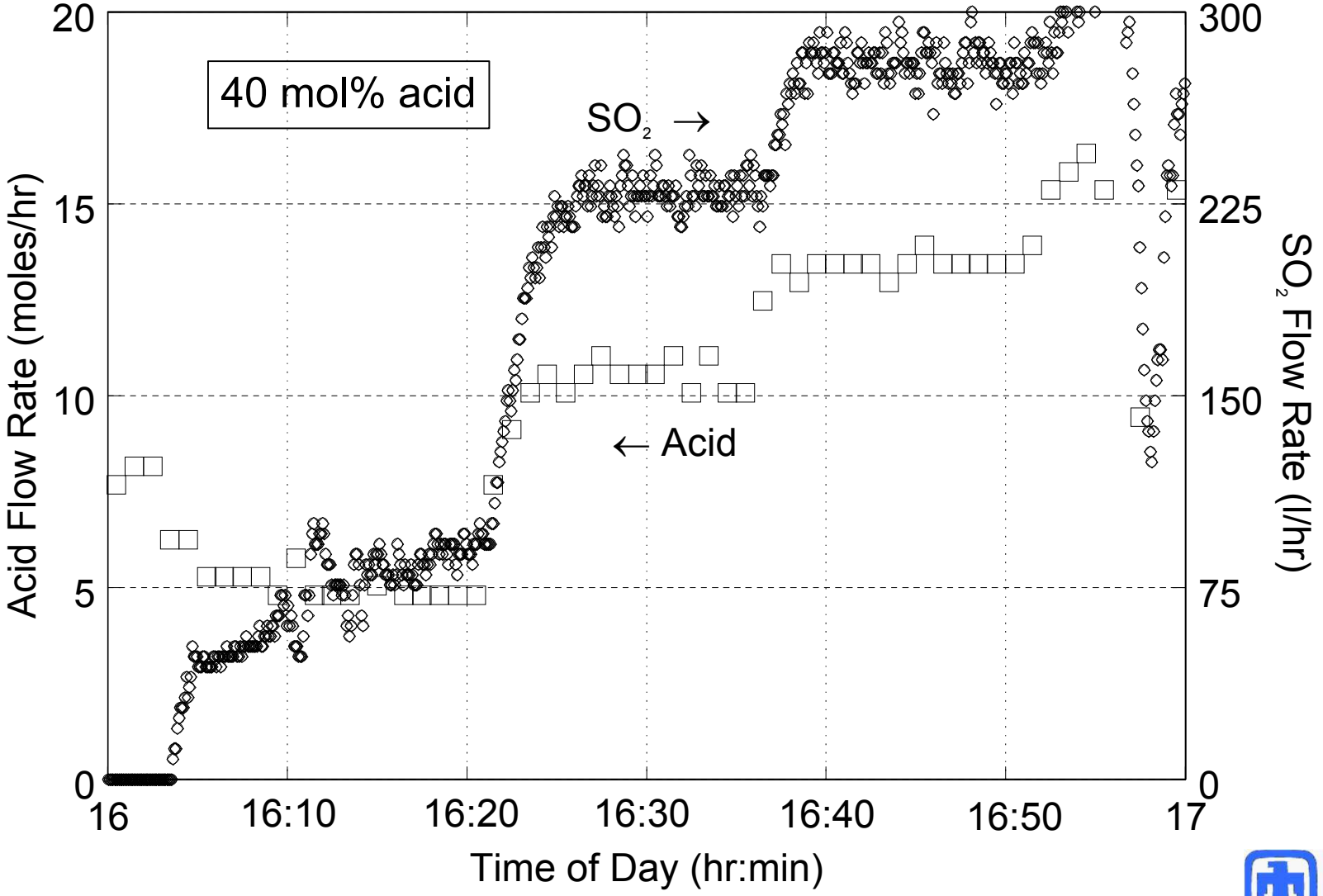
(Between Skids 1 and 2: Receives and Delivers H2SO4 and H2O)



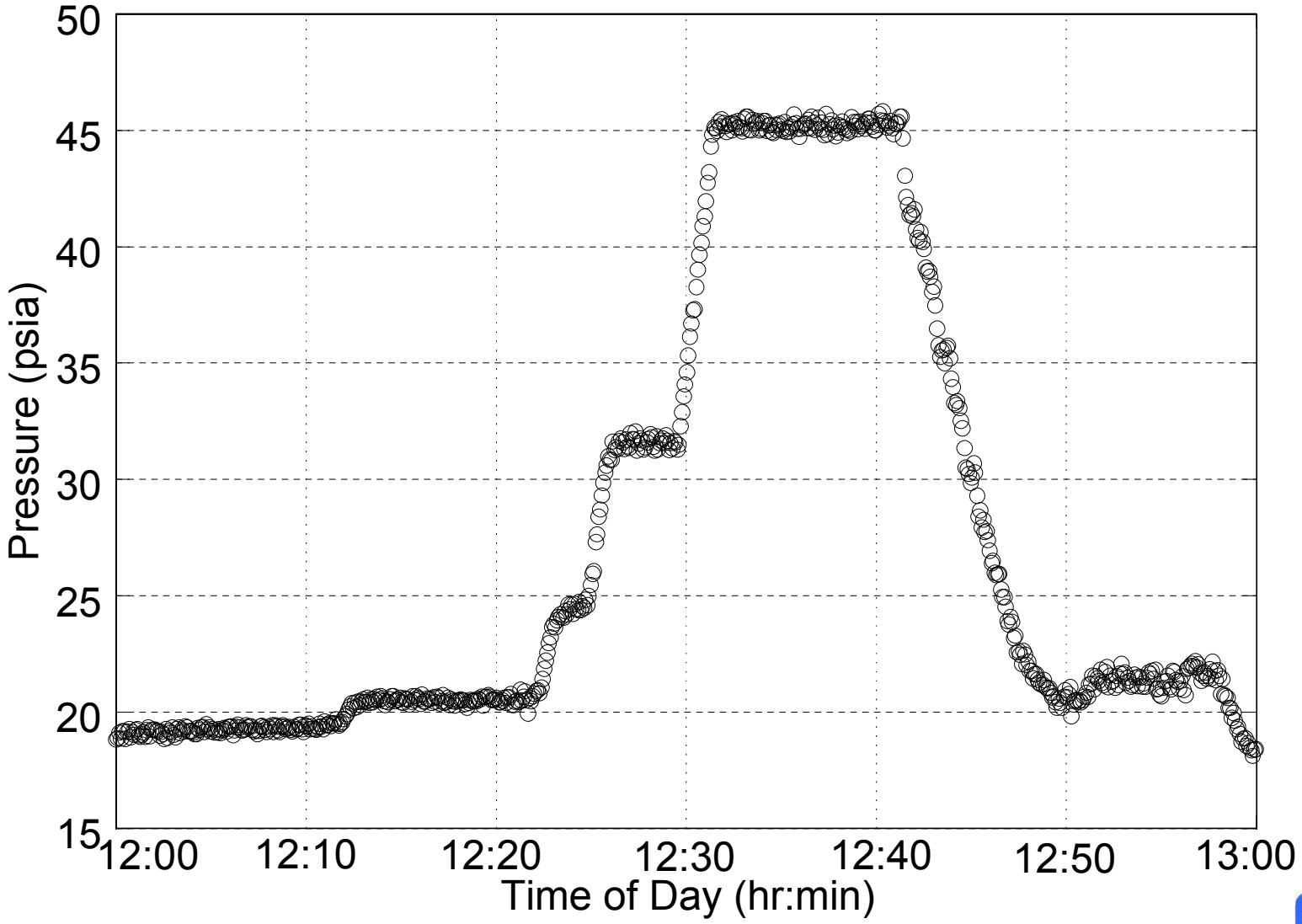
1372 mm Bayonet Tests at SNL
20 mol % Acid Feed



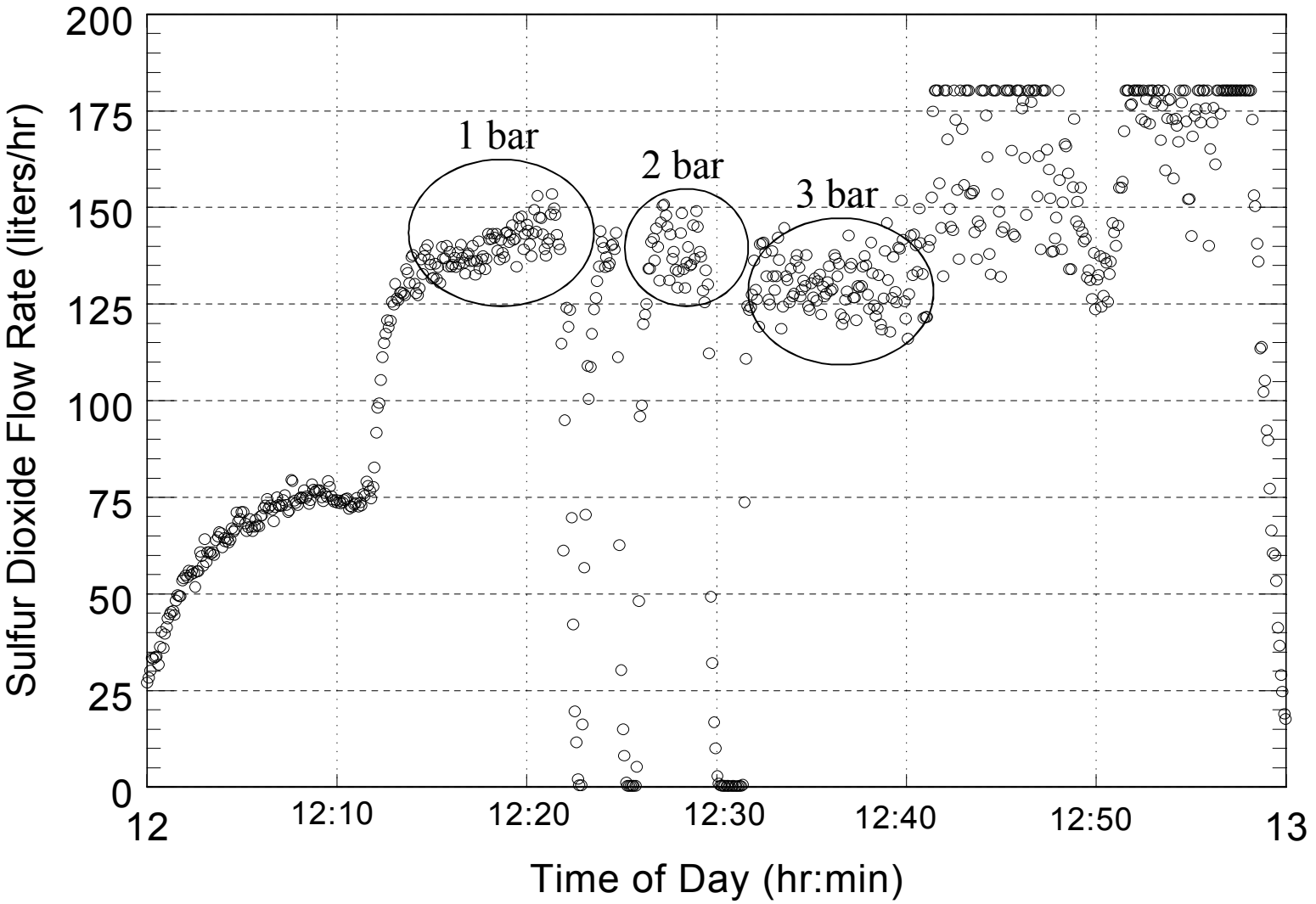
1372 mm Bayonet Tests at SNL
40 mol % Acid Feed



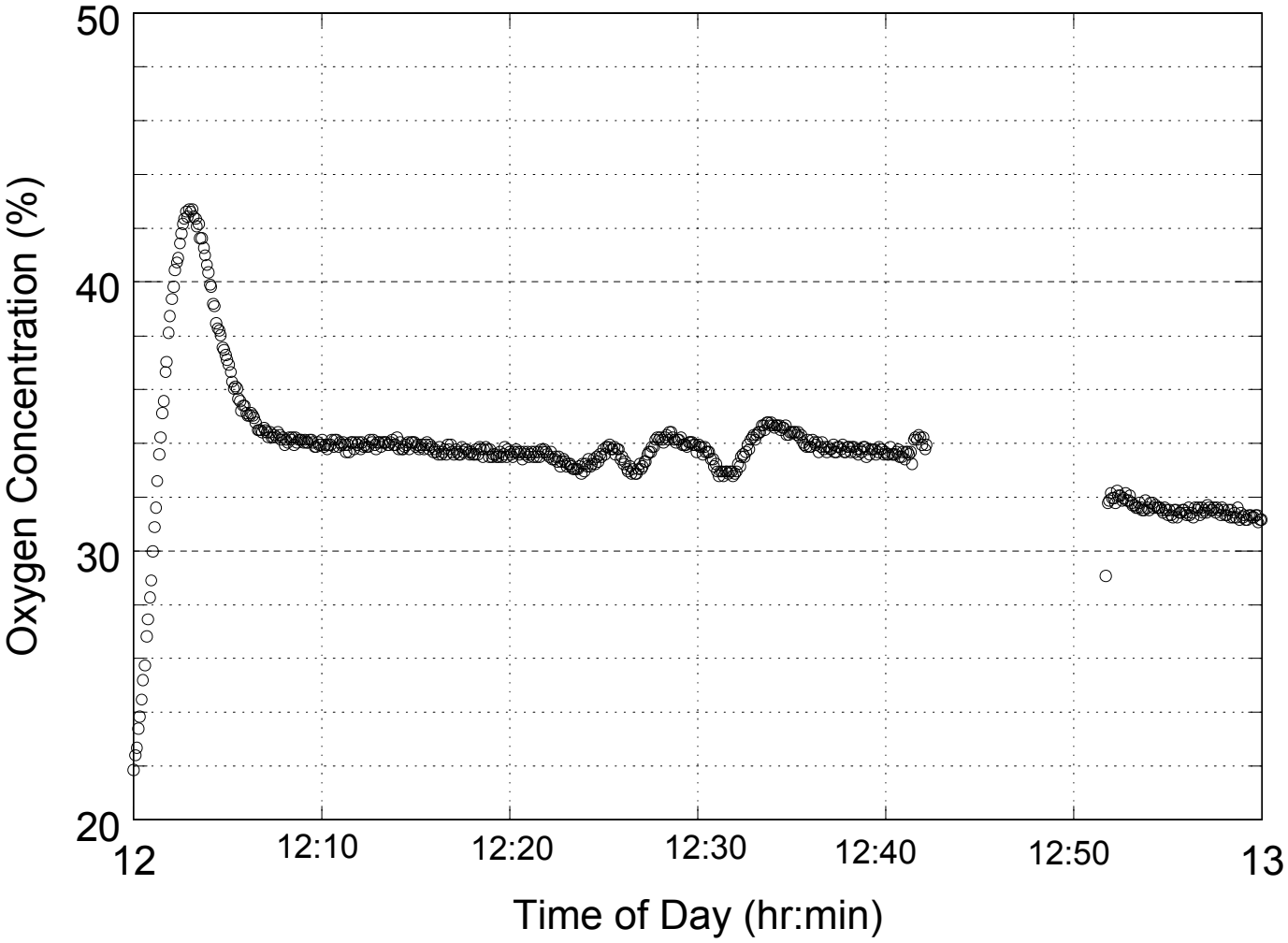
Acid conversion tests performed at GA with system pressures of 1, 2, and 3 bar (2 bar planned for ILS)



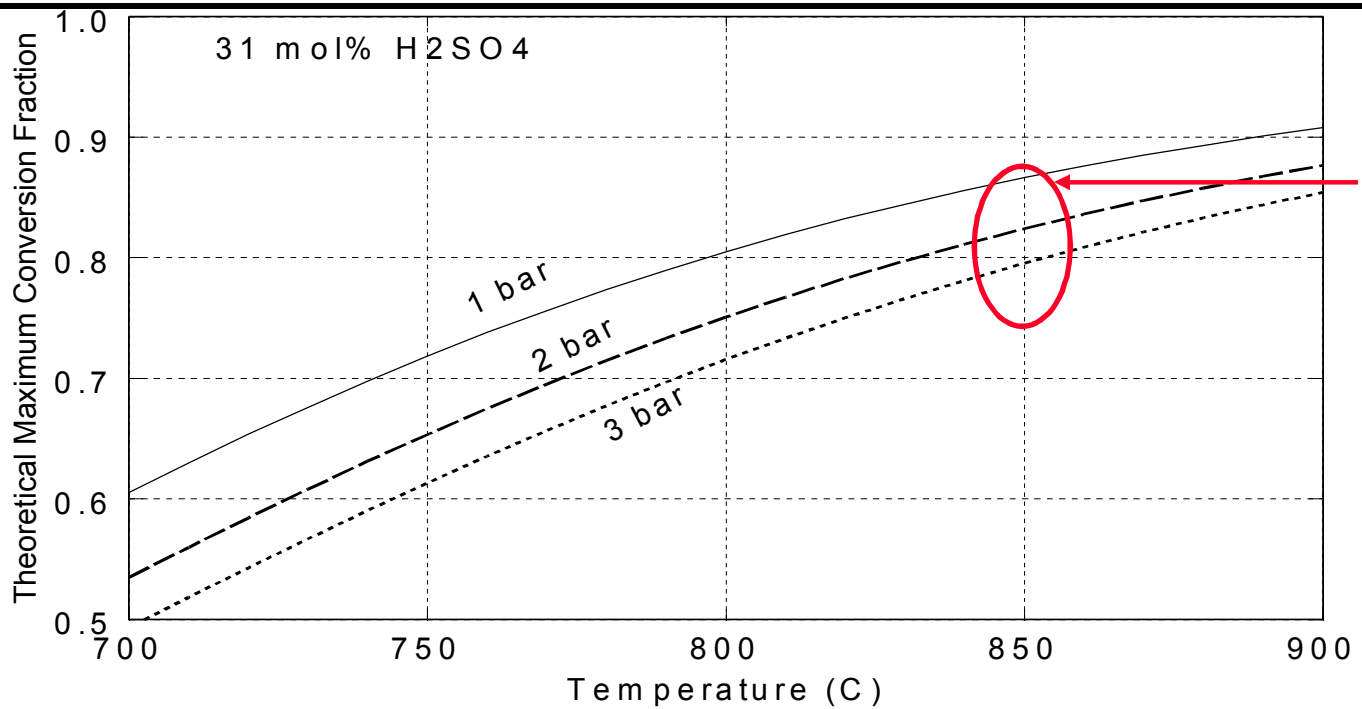
SO_2 production rate exceeded design rate of 100 liters/hr



Oxygen concentration provides confirmation that product gas stream is 67% SO_2 and 33% O_2



Acid conversion fraction is comparable to theoretical maximum conversion



Operating range

Pressure	Acid flow rate (moles/hr)	Theoretical maximum conversion fraction at 850 °C	Theoretical maximum SO_2 production rate (liters/hour)	Experimental SO_2 production rate (liters/hour)
1 bar	3.6	0.86	77	75
1 bar	7.1	0.86	152	145
2 bar	7.1	0.82	145	140
3 bar	7.1	0.80	141	135

Technical Accomplishments/Progress
Summary (1 of 2)

- **Full-scale (1372 mm) SID acid decomposition experiments performed at 850 °C and 1 – 3 bar pressure.**
  - Experiments performed with 20, 31, and 40 mol% acid feed.
  - Acid conversion 40% - 80%
    - Higher conversion ⇔ slower flow
    - Higher conversion ⇔ more concentrated acid feed
    - Higher conversion ⇔ lower pressure
  - 1372 mm SID for Integrated Lab-Scale capable of > 200 L-H_2/hr.

Technical Accomplishments/Progress
Summary (2 of 2)

- **Integrated Lab-Scale Skid progress**
  - Lexan enclosure: 1.2 m x 1.2 m base, and 2.4 m tall.
    - Continuously vented through charcoal filtration system
    - Secondary lexan enclosure with charcoal filtration within primary enclosure to minimize SO_2 hazard
    - Replaced Teflon tubing with glass-lined steel and Teflon tubing encased in steel tubing
  - Tests performed at GA with acid over the range of 1 – 3 bar
  - Exceeded objective of 100 l/hr SO_2 at 2 bar to be delivered to Bunsen reactor
  - NO corrosion observed

Next Steps

- Dec 2007 - Complete performance mapping of system parameter space of acid flow rate and acid concentration
- Mar 2008 – Complete Phase 1 testing of H_2SO_4 skid with integrated S-I cycle
- FY 2008 - Complete integrated S-I cycle testing