

Bench-Scale Silicone Process for Low-Cost CO₂ Capture



GE Global
Research

GE Global Research
GE Energy
Milliken/SiVance



GE Energy

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DOE Contract: DE-FE0007502



2012 NETL CO₂ Capture
Technology Meeting
July 10, 2012

Overview

27 Month, \$3.75M Program to Develop a Silicone Process for CO₂ Capture

Program Team



GE Global Research

- Bench-Scale Design and Testing of Absorption/Desorption Process
- Materials of Construction



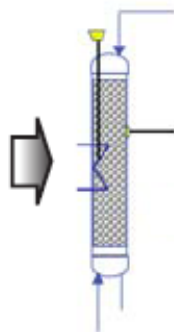
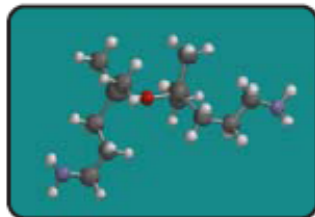
GE Energy

- Modeling and Design of Integrated Energy Systems
- Economic Analysis
- Technical and Economic Feasibility Study



- Optimized Process for Solvent Synthesis
- Large Scale Manufacture of Silicone Solvent
- EH&S Risk Assessment

Program Objective: Design and optimize a new process for novel silicone CO₂ capture solvent and establish scalability and potential for commercialization of post-combustion capture of CO₂ from coal-fired power plants. A primary outcome will be a system capable of 90% capture efficiency with less than 35% increase in the cost of energy services (COE).



Technical Approach

- Design and construct bench-scale unit and obtain parametric data to determine key scale-up parameters
- Perform an EH&S and technical and economic assessment to determine feasibility of commercial scale operation
- Develop material manufacturing plan
- Develop scale-up strategy

Outcomes

- Strategy for future scale-up
- Technical and economic feasibility determined
- Environmental assessment

Anticipated Benefits of the Proposed Technology

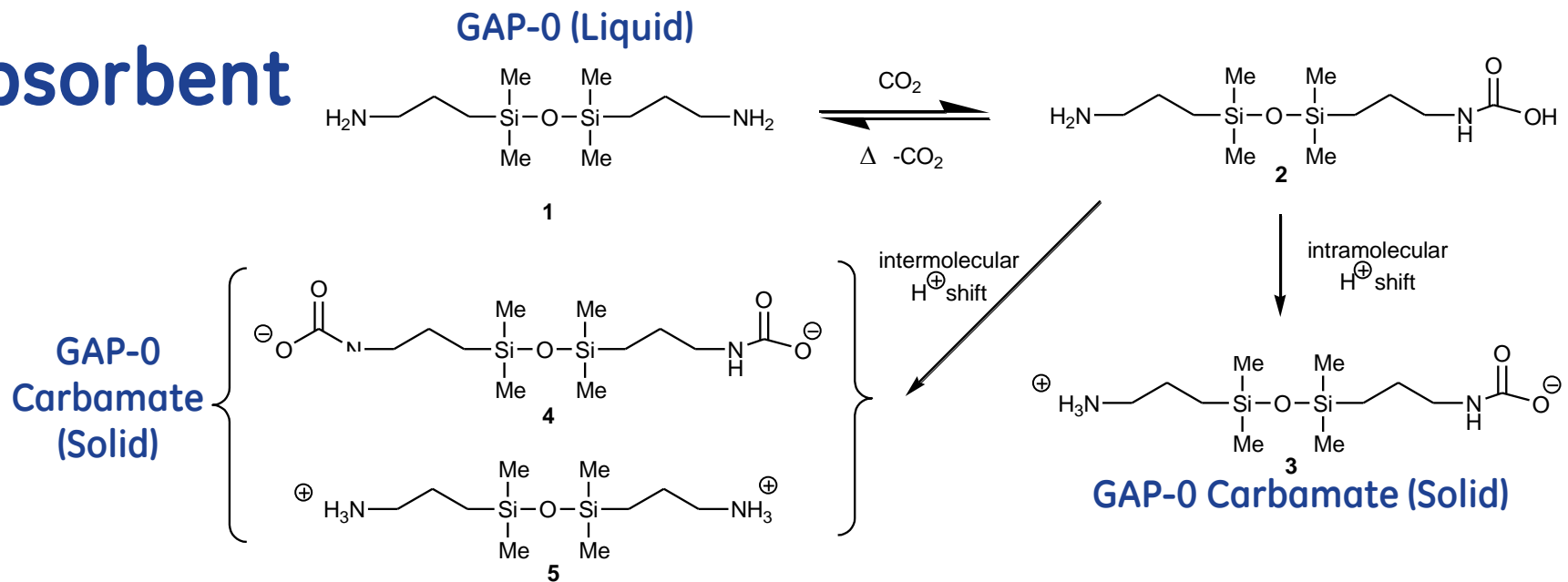
- 90% CO₂ capture with <35% COE increase

- Continuation of previous DOE/NETL funded project (DE-NT0005310)
- Current project has 2 phases
 - Phase 1: 10/1/2011 to 12/31/2012
 - Phase 2: 1/1/2013 to 12/31/2013



imagination at work

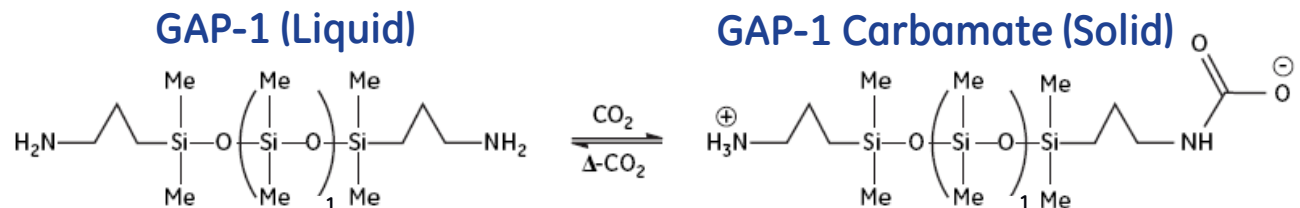
Absorbent



- GAP-0 demonstrates 17.7% wt gain of CO₂ (10.2% wt gain for 30% MEA/H₂O)
- Co-solvent required to inhibit solidification (50 wt% triethylene glycol, TEG)
- Even in a 50/50 (wt/wt) mixture of GAP-0/TEG, eventually carbamate precipitates

GAP-1_m Absorbent Composition

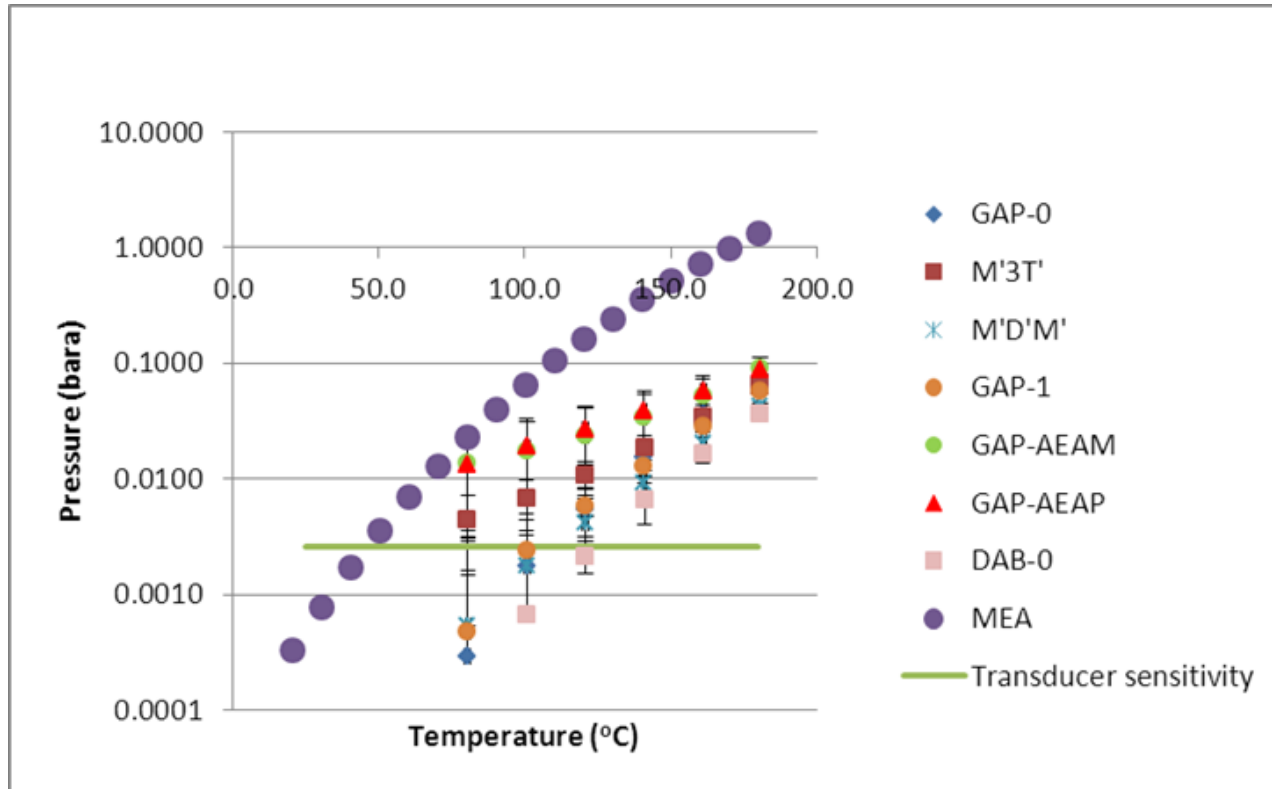
- 40% GAP-0
- 33% GAP-1
- 19% GAP-2
- 8% GAP-3



Carbamate does not precipitate in a
60/40 (wt/wt) GAP-1_m/TEG mixture

Vapor Pressure

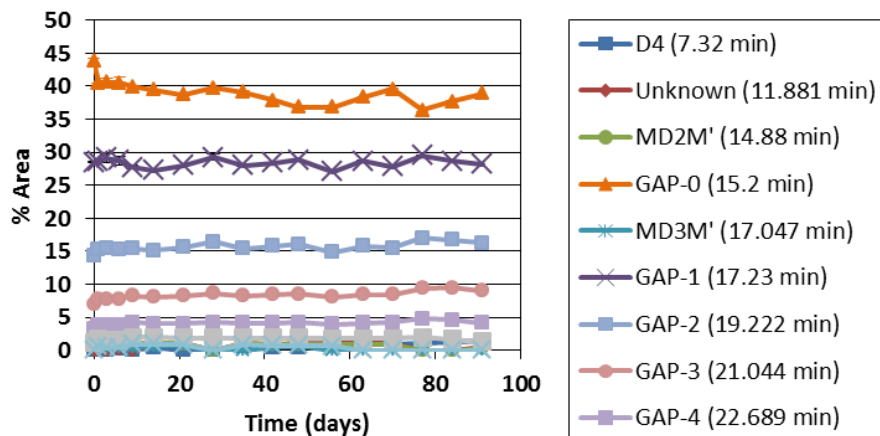
All aminosilicone materials tested exhibited vapor pressures < MEA



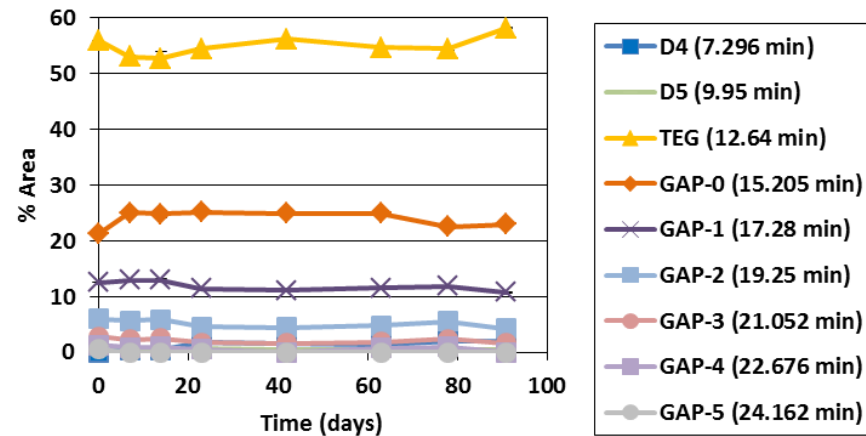
Lower absorbent vapor pressure
simplifies CO₂ desorption process

Thermal Stability Measured by GC

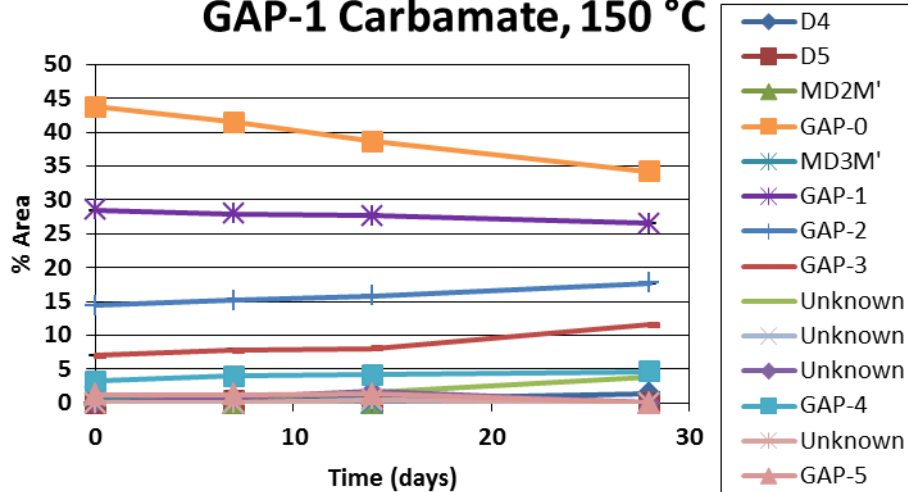
% Area in GAP-1, 150 °C



% Area in 60:40 GAP-1:TEG, 150 °C

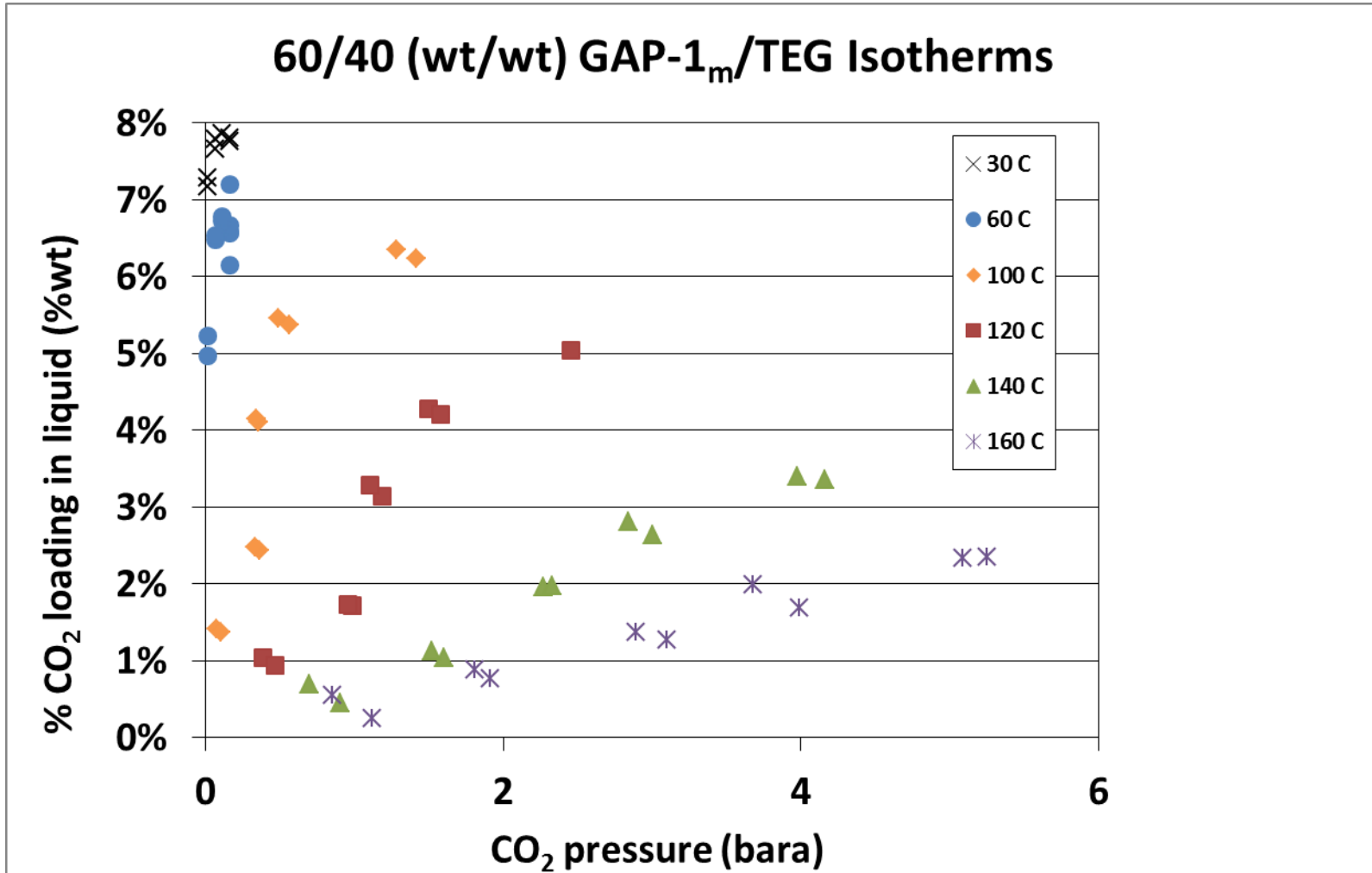


GAP-1 Carbamate, 150 °C



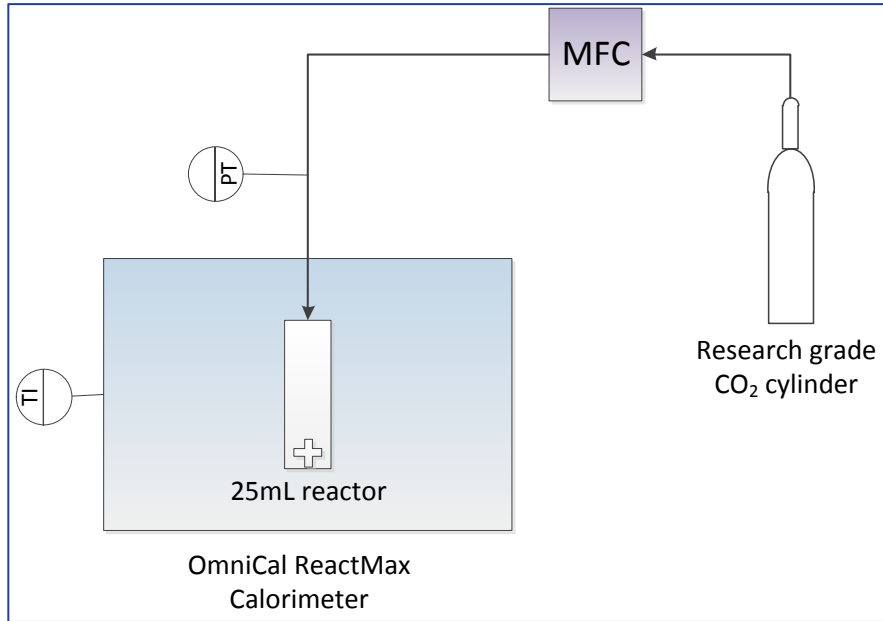
- Thermal stability of GAP materials is high
- Carbamate materials have lower thermal stability
 - GAP-0 converts to higher MW GAP materials
 - Have discovered additives that greatly improve thermal stability

Isotherms



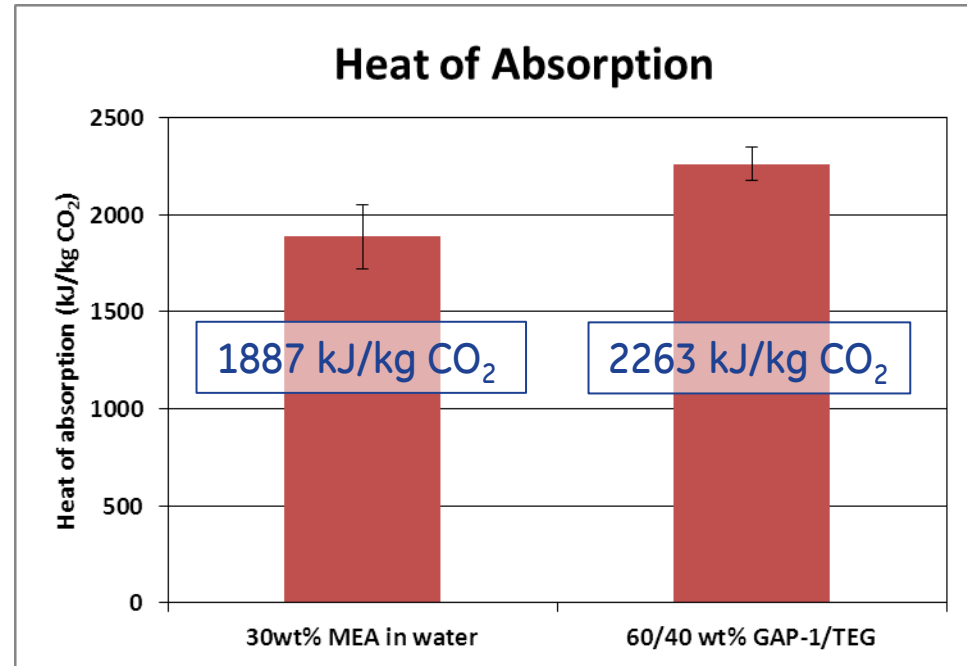
- The maximum possible working CO₂ capacity can be determined

Heat of Absorption of CO₂



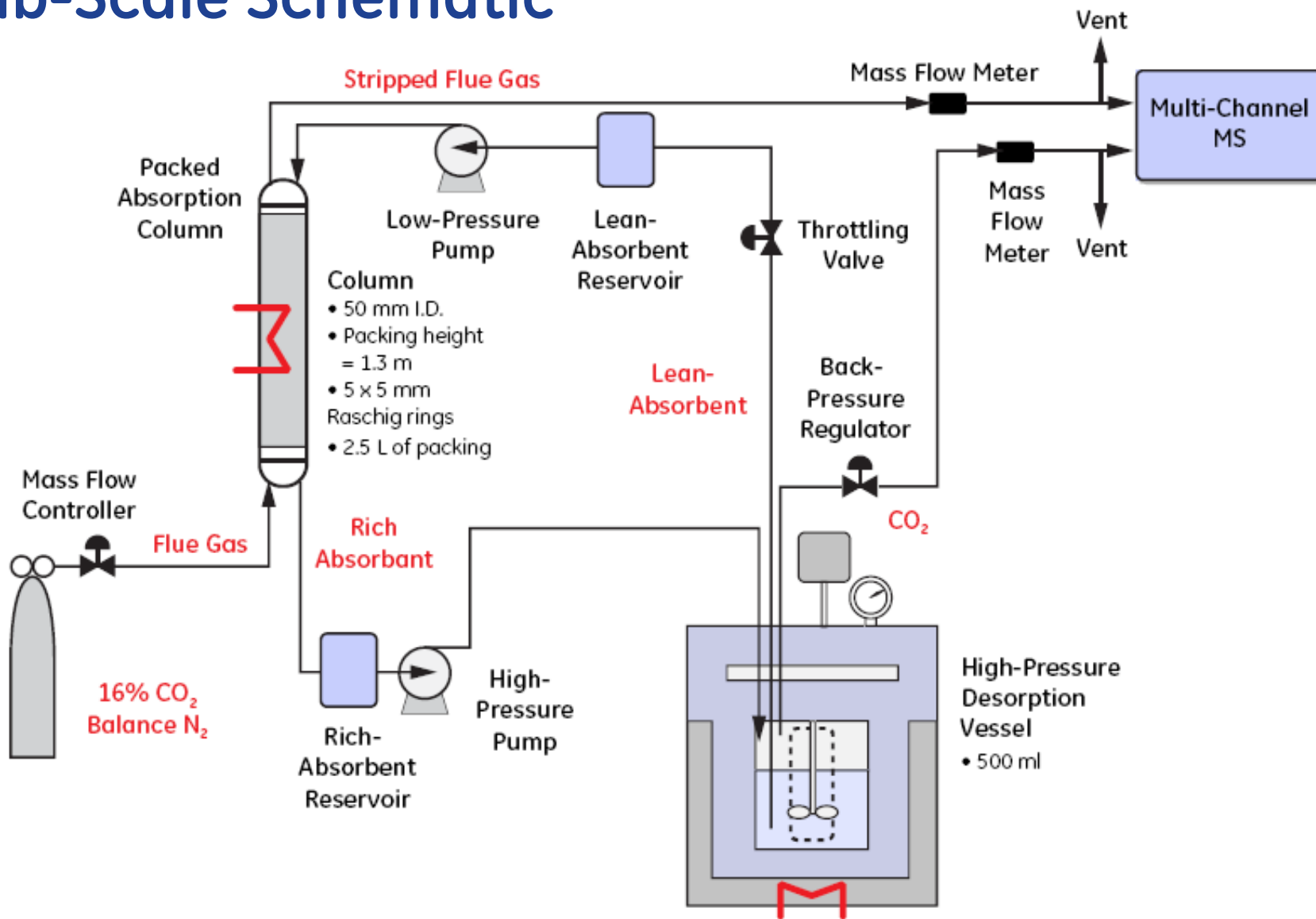
Conditions:

- T = 40 °C
- 14 doses of 20 SCC CO₂
- Magnetically stirred

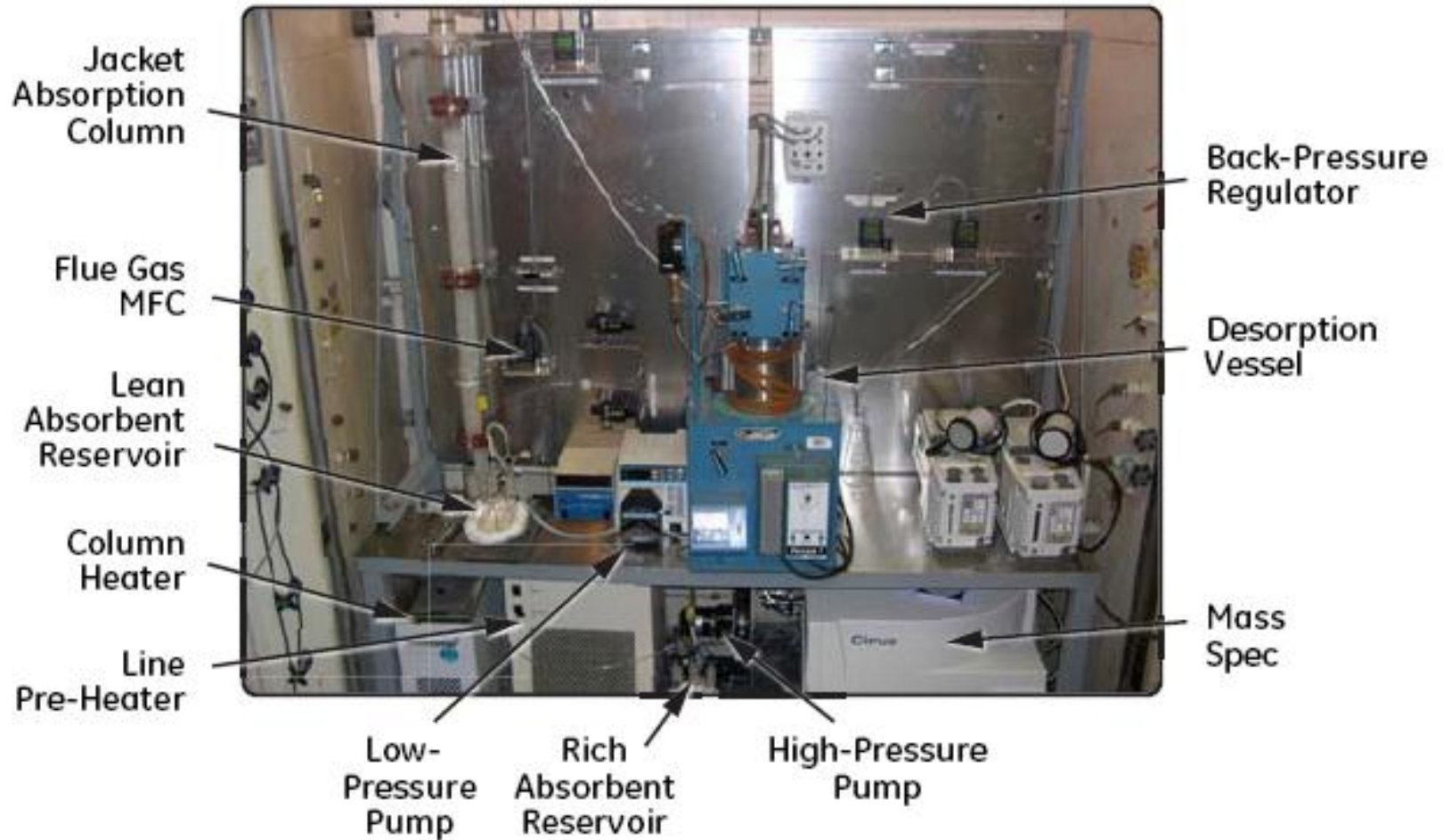


Error bars - 95% CI

Lab-Scale Schematic

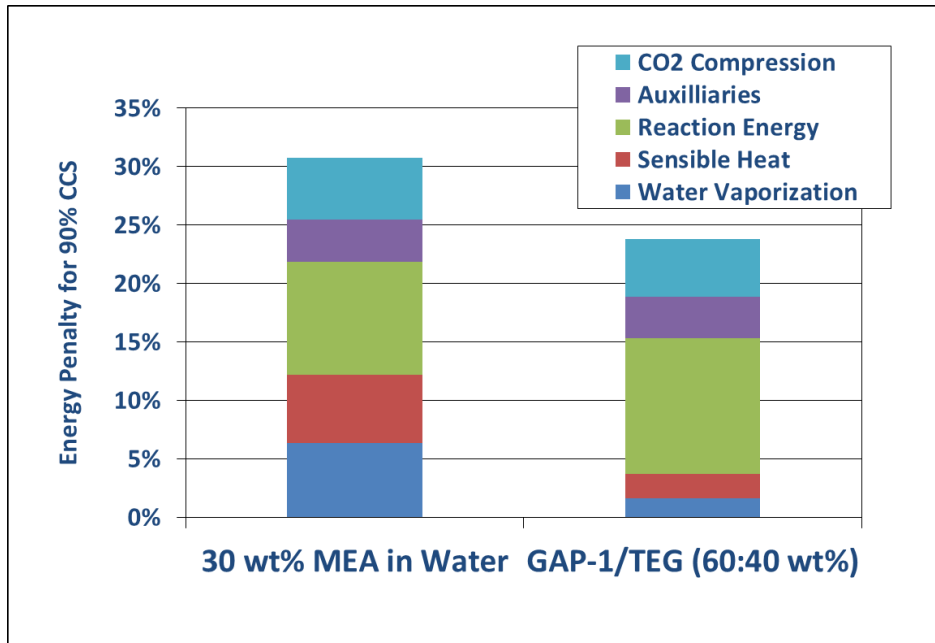
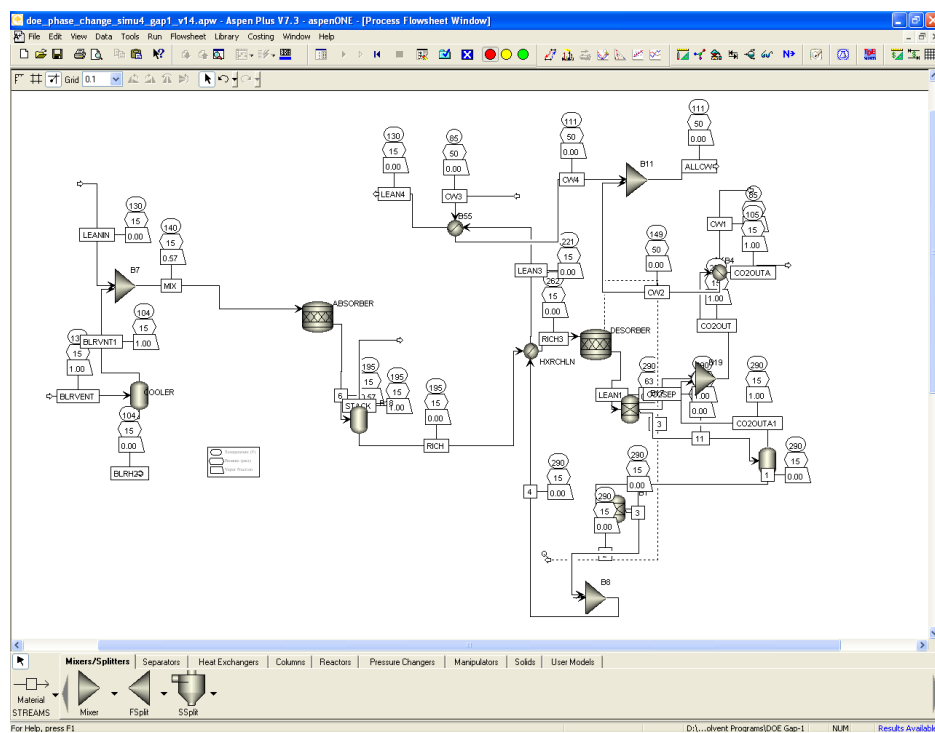


Lab-Scale System



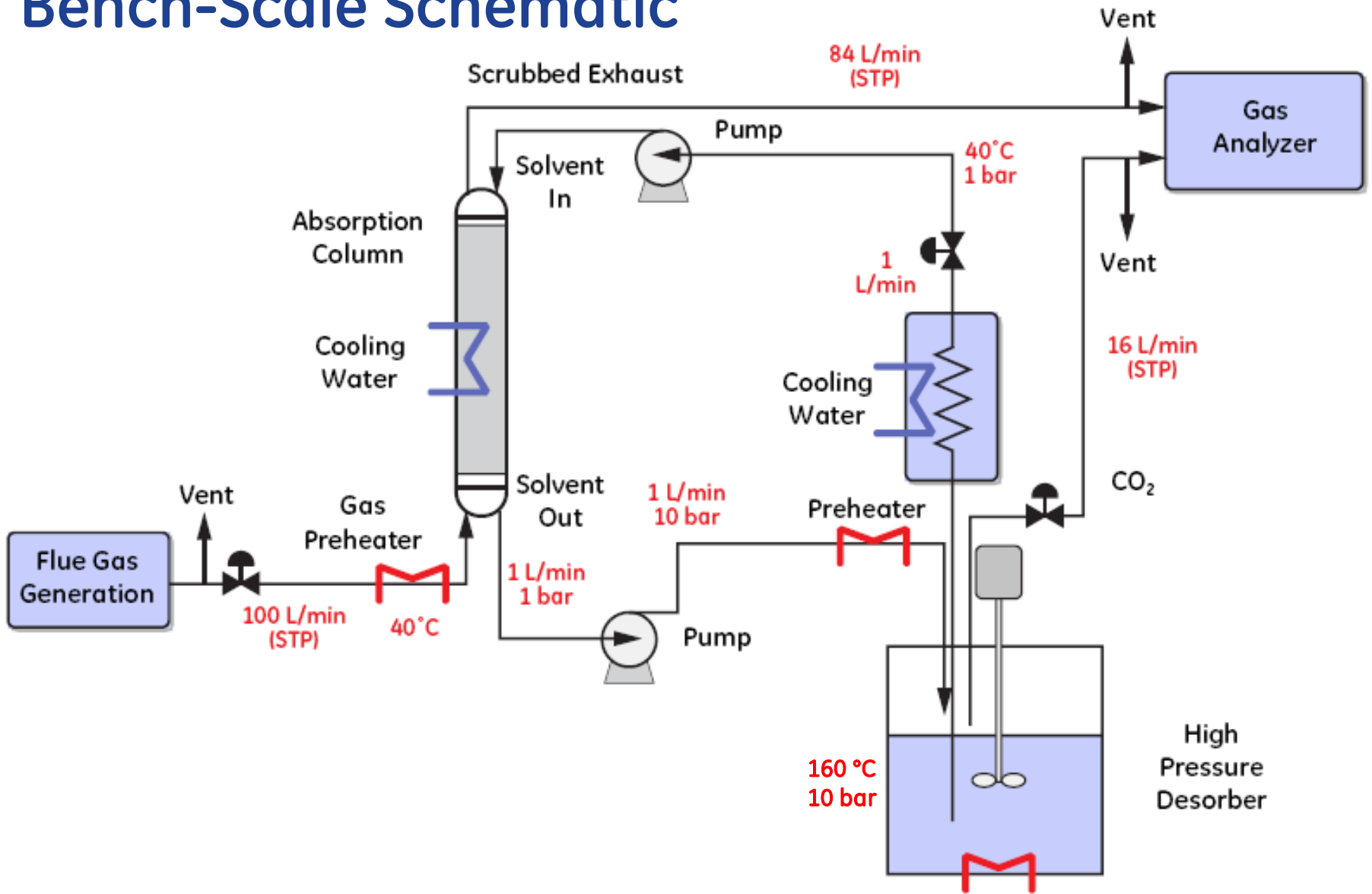
- Successfully ran numerous multi-hour experiments where solvent was cycled continuously between the absorber and desorber
- Was able to achieve >90% CO₂ capture

Energy Penalty



- ASPEN Plus model built for CO₂ separation using GAP-1/TEG; Updated with experimental results
- GAP-1/TEG energy penalty for the overall system ~24% vs. ~30% for MEA

Bench-Scale Schematic



Bench-Scale P&ID

G-100
PORTABLE GENERATOR
GENERAC MODEL 6900SE
9900 WATT W/ ELECTRIC START
120/240VAC, 1 PHASE

CH-100
BY OTHERS

HE-040
COOL HEAT EXCHANGER
COOLING 80°C TO 20°C
400 LPM OHP GAS
22,000 BTU/HR

BL-042
BOOSTER BLOWER
4" BL. DOWN FAN
5.25 CFM

F1-041
5 MICRON PARTICULATE FILTER

HE-000
ABSORBER REHEATER
HEAT 32°C TO 40°C
200 LPM OHP GAS
1,600 BTU/HR

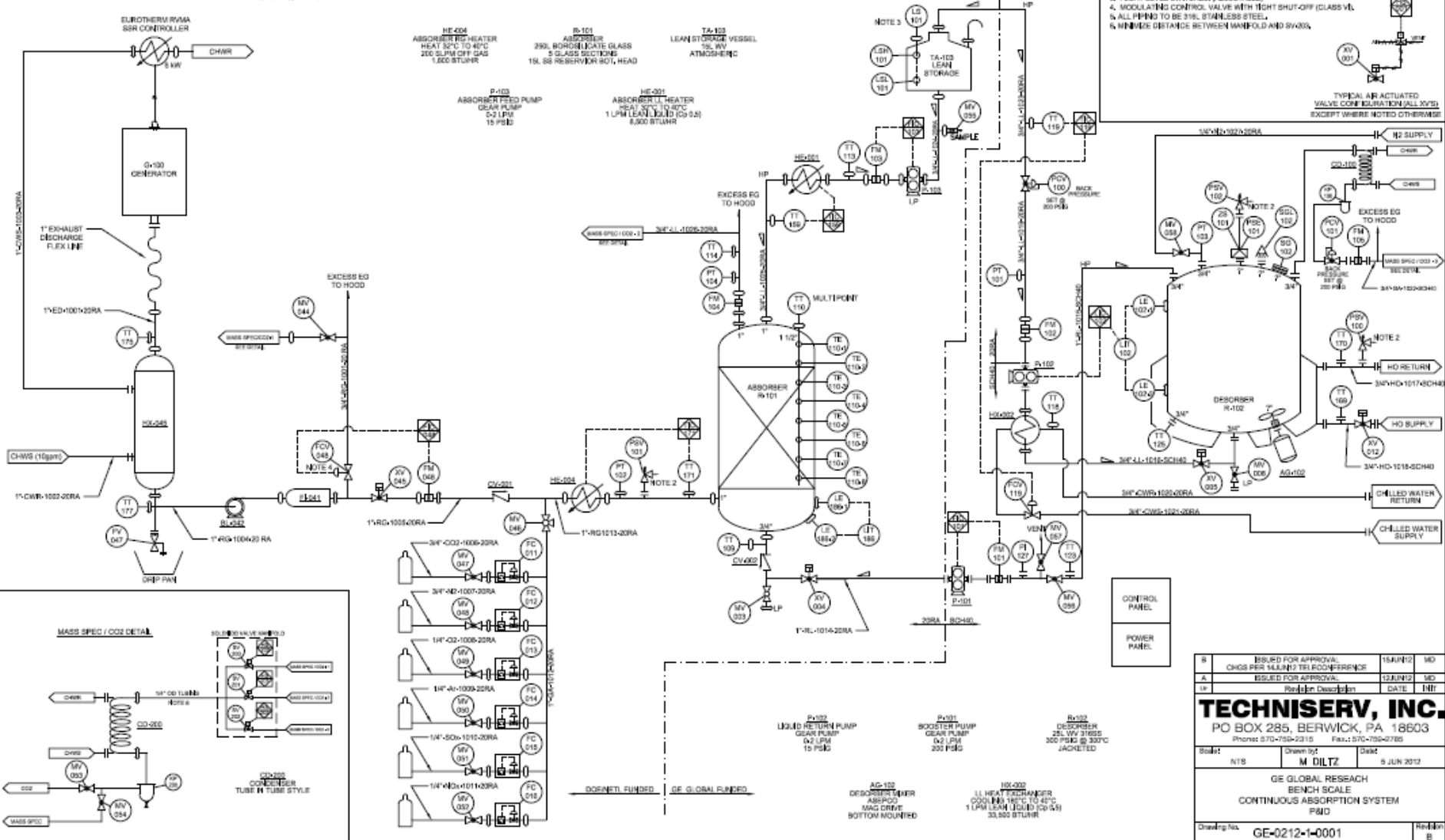
P-100
ABSORBED PUMP
GEAR PUMP
0-2 LPM
15 PSIG

R-101
ABSORBER
290. BOROSILICATE GLASS
5 GLASS SECTIONS
18.58 RESERVUAR 80", HEAD

TA-100
LEAN STORAGE VESSEL
5L. WV
ATMOSPHERIC

HE-001
ABSORBER REHEATER
HEAT 32°C TO 40°C
1 LPM LEAN CO₂ (G) (S)
8,000 BTU/HR

- NOTES**
1. ALL VALVES TO BE FM. CLOSED UNLESS OTHERWISE NOTED.
 2. FMS TO WITHIN 6" OF FLOOR.
 3. FLOAT LEVEL SWITCHES (ADJUSTABLE)
 4. MODULATING CONTROL VALVE WITH TIGHT SHUT-OFF (CLASS IV).
 5. ALL PIPING TO BE 3/8" STAINLESS STEEL.
 6. MINIMUM DISTANCE BETWEEN MANIFOLD AND VALVES.



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BENCH SCALE			
CONTINUOUS ABSORPTION SYSTEM			
P&ID			
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