Emissions Mitigation Technology for Advanced Water-Lean Solvent Based CO_2 Capture Processes

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Development History for Novel, Non-Aqueous Solvents

Technology Status

- Cumulative DOE funding > $9 MM and more than $2 MM funding from RTI industrial partners
- Solvent development work finalized
- Pilot testing completed at SINTEF, Norway and National Carbon Capture Center (NCCC)
- Pre-commercial demonstration (12 MW) planned at Technology Center Mongstad (TCM), Norway in FY20

Key Technical Advantages

- CO_2 Capture Technology with substantially reduced energy consumption
- Minimum changes to existing process to realize NAS optimal performance
- Commodity-scale production ready

Impact

- Long-term potential for large scale CO_2 capture applications
- Commercialization path via process technology licensing
- Application potential for high-efficiency acid gas separations

NAS CO_2 Capture Technology Path to Market

From lab to large scale (12 MW) demonstration through series of projects

Lab-Scale Development & Evaluation (2010-2013)

Solvent screening and Lab-scale evaluation

~$2.7MM

Large Bench-Scale System (RTI facility, 2014-2016)

Demonstration of key process features (≤ 2,000 kJ/kg CO_2) at bench scale

~$3 MM
6kW

Pilot Testing at Tiller Plant (Norway, 2015-2018)

Demonstration of all process components at pilot scale

~$3MM
60 kW

Pilot Testing at SSTU (NCCC, 2018)

Degradation, emission, and corrosion characterizations under real flue gas

~$0.75MM
50 kW

Emissions control (Tiller, 2018+)

Effective emissions mitigation strategy for WLS at engineering-scale

~$3.5MM

Engineering-Scale Validation (2018+)

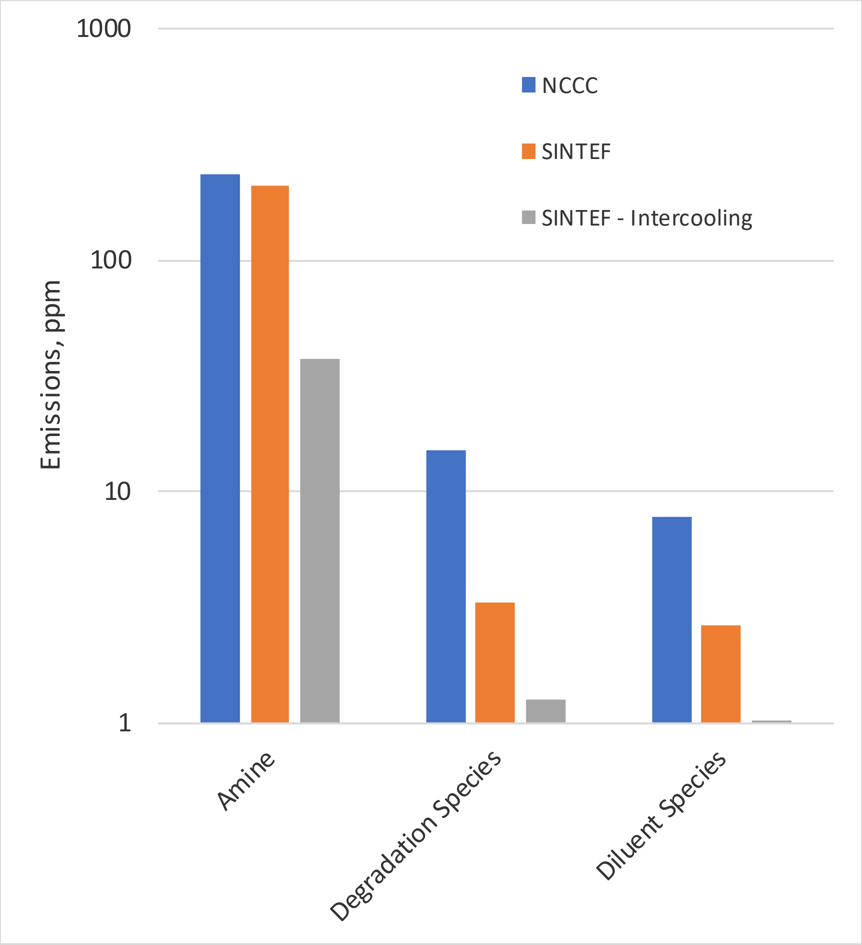
Pre-commercial Demonstration at Technology Centre Mongstad, Norway (~12 MWe)

Test in late 2020

~$21MM
12 MW

NCCC and Tiller Emission results

- Similar emissions levels and species seen at SINTEF and NCCC
- Intercooling reduces emissions by almost 10x
- Largest minor emissions include hydrophobic diluent species and other degradation species



Project Summary

Objective:

Develop and optimize the emission control solutions to reduce the amine emission for advanced, 2nd generation solvent –WLS class

Key Metrics

- Emissions from absorber&desorber
- Solvent loss and make-up cost reduction
- Technoeconomic and EHS evaluation

Specific Challenges

- Aerosols generation and characterization
- Amine reclaiming unit and process integration
- Organic wash solvent screening

Timeframe:

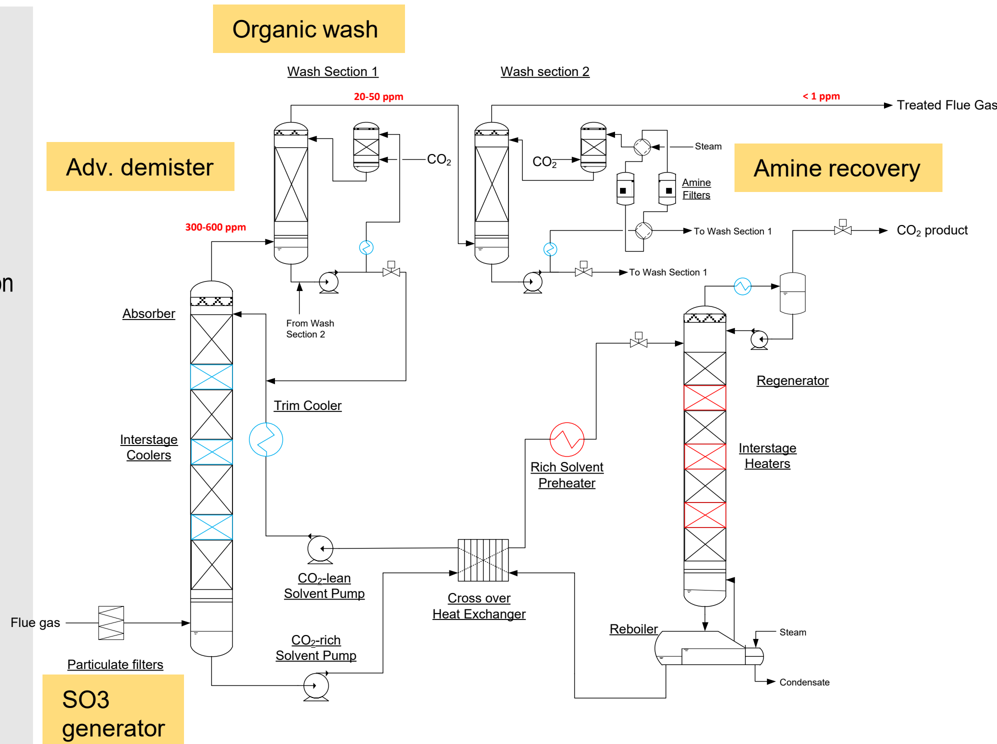
BP1 10/01/18 to 03/31/20

BP2 04/01/20 to 09/03/21

Budget:

BP1 Federal $1.7MM Cost Share $0.4MM

BP2 Federal $1.2 MM Cost Share $0.4 MM



Potential emissions control technologies for WLS systems to be incorporated at the RTI's BsGAS

Project Team

Team Member	Role	Expertise
RTI International	Prime recipient, project management, developer of NAS technology, emissions characterization, solvent screening, ECT design and modeling, and economic analyses	▪ Effective project management and execution under DOE cooperative agreements ▪ Lead developer of NAS CO_2 capture technology ▪ Process design, modeling, and engineering capabilities ▪ Process technology scale-up and operation from lab to large precommercial demonstration systems ▪ Aerosol emissions characterization
The Linde Group	Technical advisory and contributor to joint-emission report	• Leading industrial gas supplier • CO2 capture plant design and pre-commercial scale demonstration • Advance front-end emission control equipment design and fabrication
CO_2 Technology Centre Mongstad	Technical advisory and EH&S support	• World leading test facility for CO_2 capture • EH&S and quality standards

BP1 Tasks and Project Goals

BP1 Tasks

Task 1.0: Project Management and Planning

Task 2.0: Establish emission baseline without ECT

- Aerosol generation at BsGAS
- Baseline measurement
- Empirical model development

Task 3.0: Prototype ECT for WLSs evaluation at RTI's BsGAS

- 2nd wash column and amine recovery process
- Evaluation of BsGAS with ECTs

Project Goals

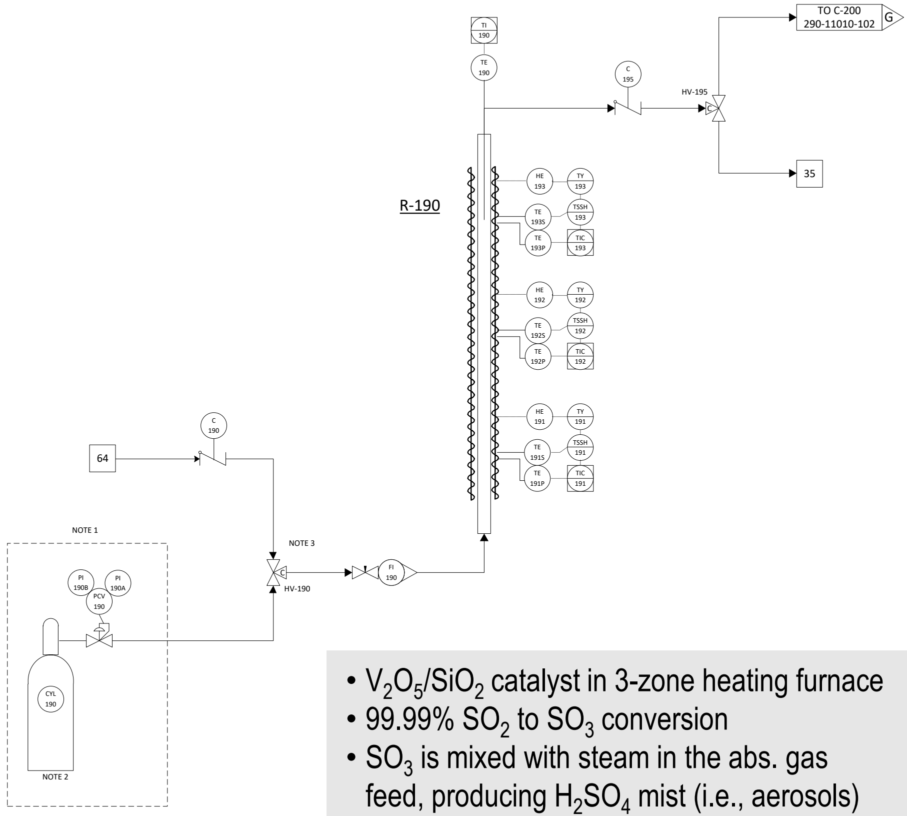
- Control and manage amine emissions
- Identify emission pathways for WLSs
- Model the amine emission
- Refine Techno-economic analysis
- Gain operational experience on WLS process with ECTs

BP1 Key Tasks

Key Tasks	Approaches/ planned Activities	Planned Completion Date
Develop method to monitor and quantify emissions at the BsGAS	• Install SO_3 injection at BsGAS • Particle counter and aerosols quantification equipment tie-in	Completed
Update BsGAS flow sheet with emission control equipment necessary to reduce amine emissions with > 99% efficiency	• Install, commission, and evaluate ECTs at BsGAS	Completed
Baseline data for amine emissions using two water-lean solvents	• Parametric testing on 2 solvent candidates	08/31/19
Empirical process model for amine emissions from water-lean solvents with < 10% average absolute deviation based on critical process parameters	• Regression on experimental results	03/31/20
Complete testing of emission reduction performance at BsGAS to demonstrate amine emissions reduction to < 10 ppm	• Parametric testing	03/31/20

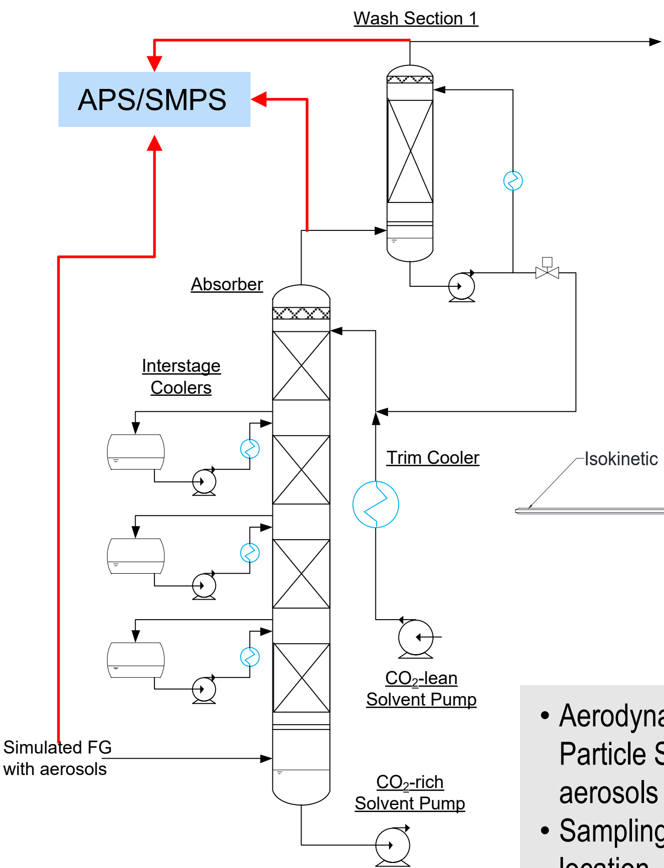
SO_3 Generator at BsGAS: installation and setup

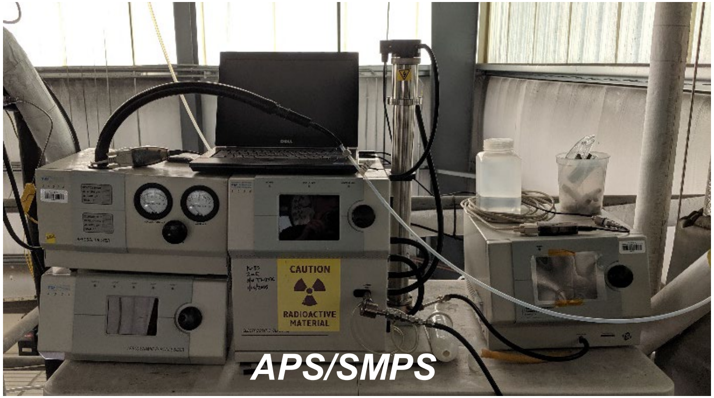
SO_3 generator

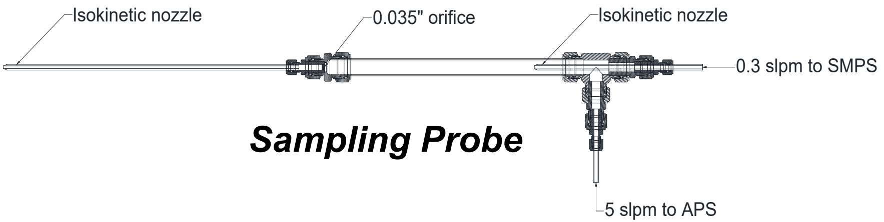


- V_2O_5/SiO_2 catalyst in 3-zone heating furnace
- 99.99% SO_2 to SO_3 conversion
- SO_3 is mixed with steam in the abs. gas feed, producing H_2SO_4 mist (i.e., aerosols) feeding the absorber
- Concentration ranges from 0-10 ppm SO_3

Characterizing Aerosols: APS/SMPS Setup





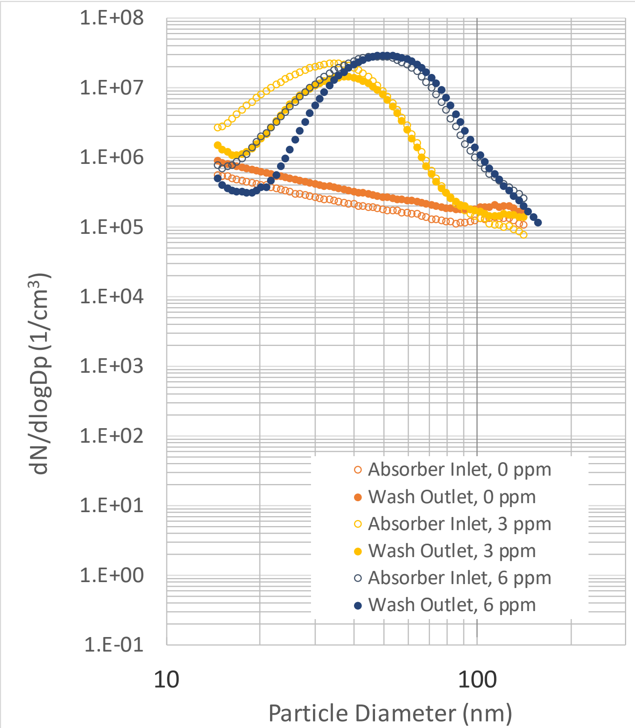


Sampling Probe

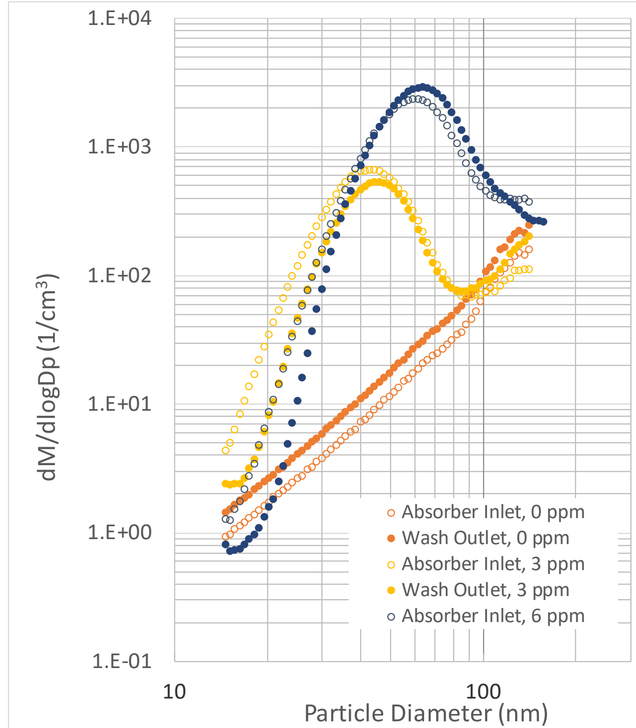
- Aerodynamic Particle Sizer (APS, 0.5-20 µm) and Scanning Mobility Particle Sizer (SMPS, 15-660 nm) were installed to characterize the aerosols from abs. inlet, outlet, and WW outlet.
- Sampling probe is designed to take isokinetic samples at each location

SO_3 Generator at BsGAS: Trial runs

Particle concentration

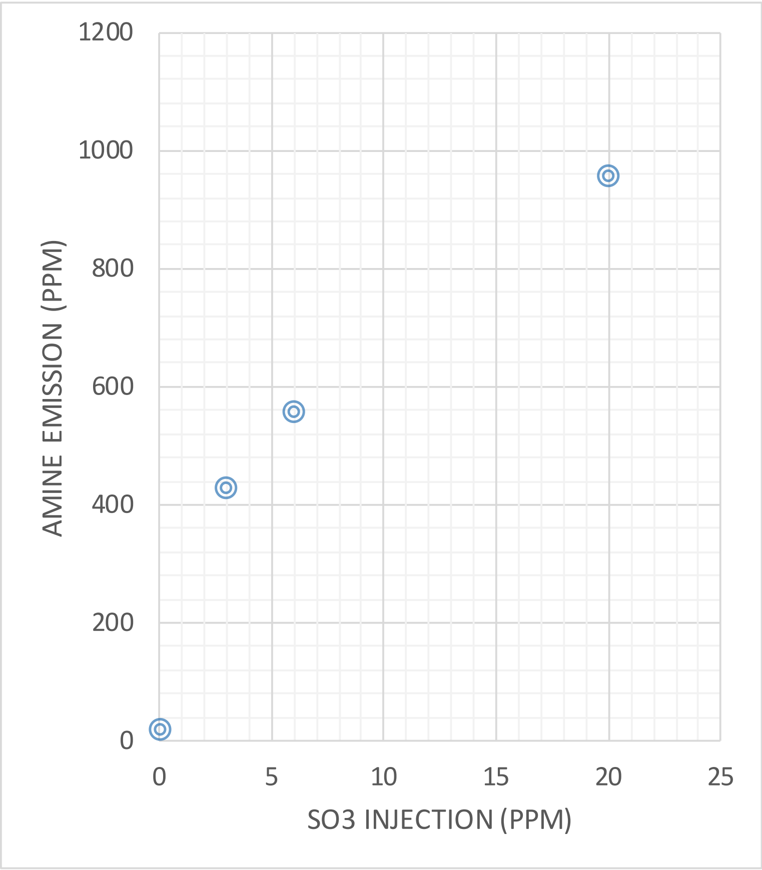


Particle mass



- Particle concentration and sizes are consistent with literature
- Aerosols grow as they travels through the process
- Large aerosols carry more mass

SO_3 Generator at BsGAS: Trial runs



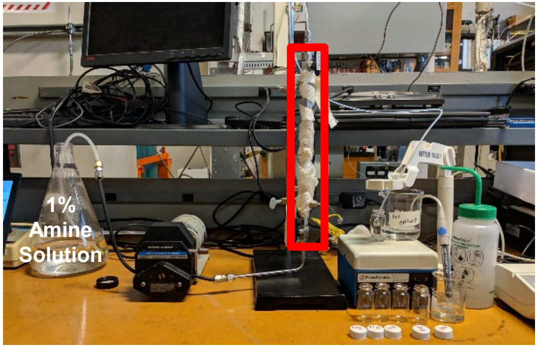
Parametric Testing

Parameters	Units	Low	Medium	High
SO_3 Injection	ppm	0	3	6
Inlet Saturation Temp	°C	20	25	30
L/G	kg/kg	3	4.5	6
Regenerator Temp	°C	95	105	115
Lean Return Temp	°C	30	40	50
IC Top	%	0	50	100
IC Middle	%	0	50	100
IC Lower	%	0	50	100

36 total runs have been scheduled, testing in progress

Amine Recovery: Sorbent Testing

Adsorption

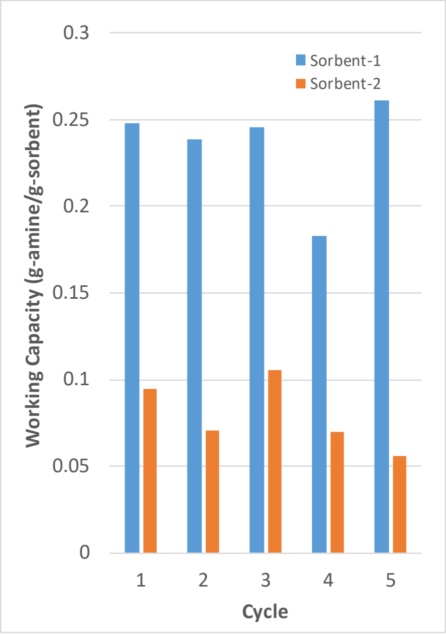


	Adsorption	Regeneration
Test Length	65 min	65 min
Sampling	4 min sample, every 10min	4-6min sample, 2 min between sample
Flow Rate	~4 mL/min 1% amine sol.	2 mL/min Steam

Regeneration

Bed - ~6 g of sorbent

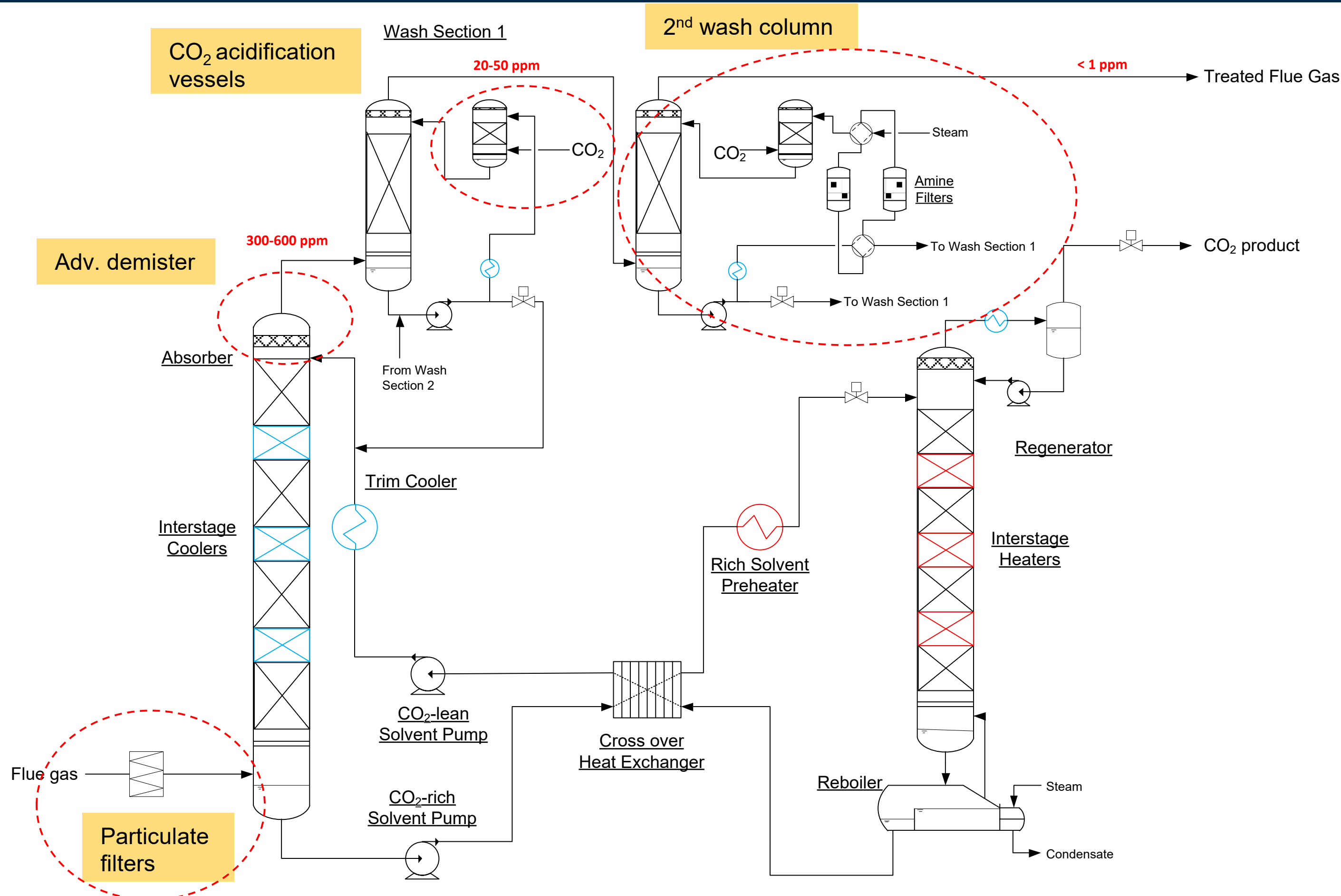
Working Capacity



- Lab setup used to screen sorbents for amine recovery
- Working capacity at different amine concentrations used to evaluate sorbents

- A top candidate was selected with working capacity of ~0.25 g-amine/g-sorbent with 1 wt% amine solution
- Kinetic parameters measured for scaling up to BsGAS system

BsGAS modifications with ECTs



Accomplishments and Path forward

Accomplishments

- Installed SO_3 Generator to generate aerosol with size distribution matches that of the actual coal-fired power plant
- Incorporated APS/SMPS for aerosol characterization and at BsGAS
- Completed detail design for the particulate filters, advanced demister, additional wash column, CO_2 acidification vessels, amine recovery beds.

Path forward

- Complete parametric testing at BsGAS: late Sep
- BsGAS modification: Oct-Nov 2019
- Evaluate the ECTs added to the BsGAS: Jan –Mar 2020
- Empirical model development: Oct-Mar 2020

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