

University of Kentucky

Pilot CO₂ Capture Demonstrations: Emissions

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UKy 15 TPD Unit at PPL's EW Brown Station

- ❑ 90+% CO₂ capture efficiency and 99+% CO₂ stream purity
- ❑ Modular, solvent-agnostic process design
- ❑ Installed and tested at coal-fired power plant
- ❑ Absorber inlet with:
 - 10-16 vol% inlet CO₂ concentrations
 - 6-12 O₂
 - <5 ppm SO₂
 - <50 ppm NO_x
 - <10 g/hr PM
- ❑ 2x3 (total 6 modules) with stand-alone integrated cooling tower
- ❑ Footprint of CCS module: 28 x 44 ft. and 75 ft. tall
- ❑ 10 solvent campaigns completed
- ❑ >8,000 operational hours
- ❑ Demonstration of process intensification and smart process control strategies
- ❑ Emission, degradation and corrosion studies published from MEA and H3-1 solvent campaigns

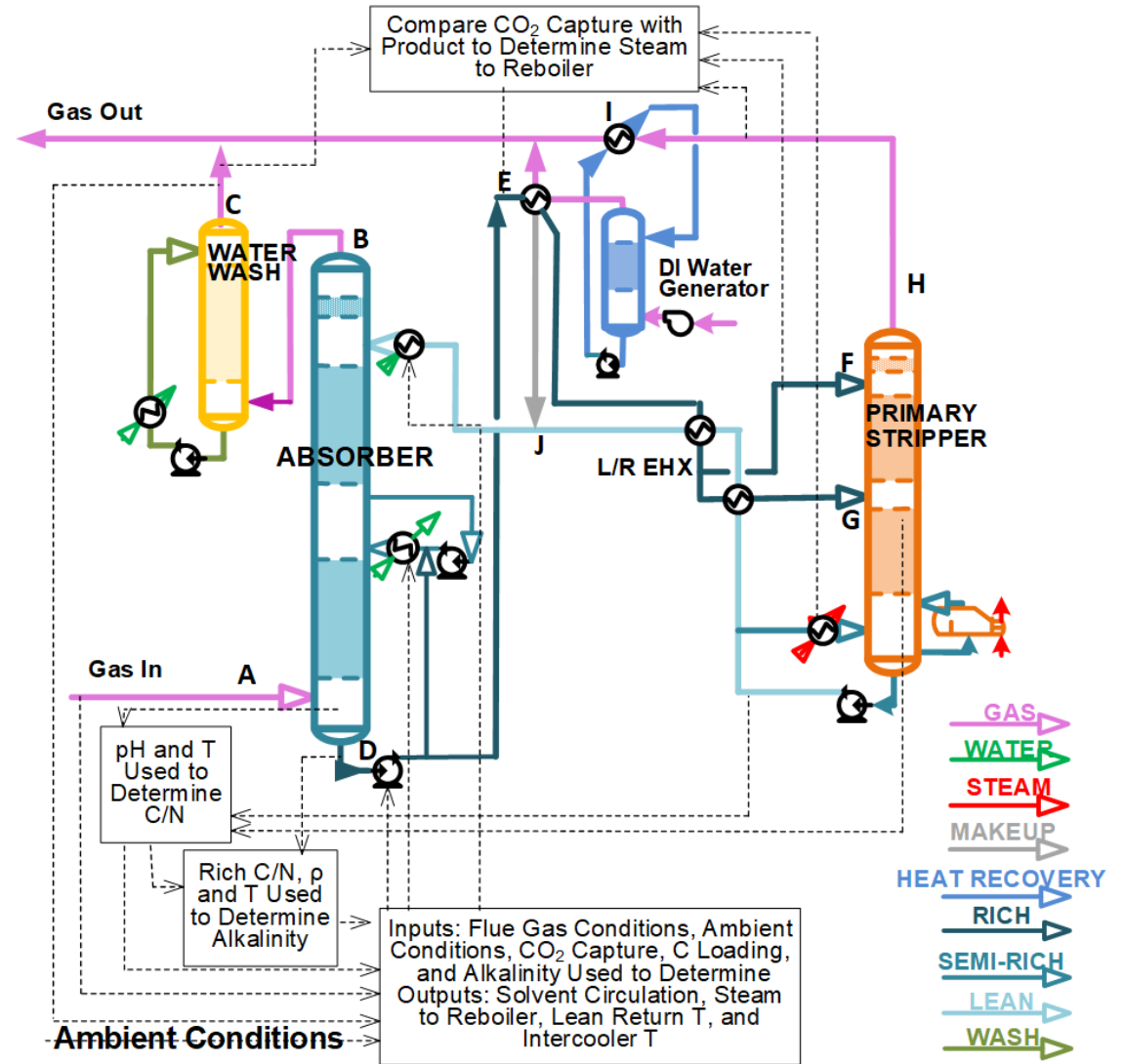
❑ Process performance
 with air dilution to
 4 vol% CO₂
 also evaluated



<https://www.weku.org/energy/2014-07-21/kentuckys-first-carbon-capture-system-unveiled>

To be Applied at 3 TPD at Nucor Steel Gallatin

- ❑ Absorber inlet with:
 - ❑ 0.5-1.5 vol% inlet CO₂ concentration
 - Significantly lower wet bulb temperature
 - higher O₂
 - similar SO₂
 - lower NO_x
 - PM to be evaluated
 - ❑ 95+% CO₂ capture
 - ❑ 3 or 4 process modules
 - ❑ Test plan to include gas sampling during operating conditions to simulate cyclic operation
 - ❑ UKy primary amine solvent applied with no stable nitrosamine formation
 - ❑ Low stripping temperature for reduced solvent degradation
- } Compared to E.W. Brown Station

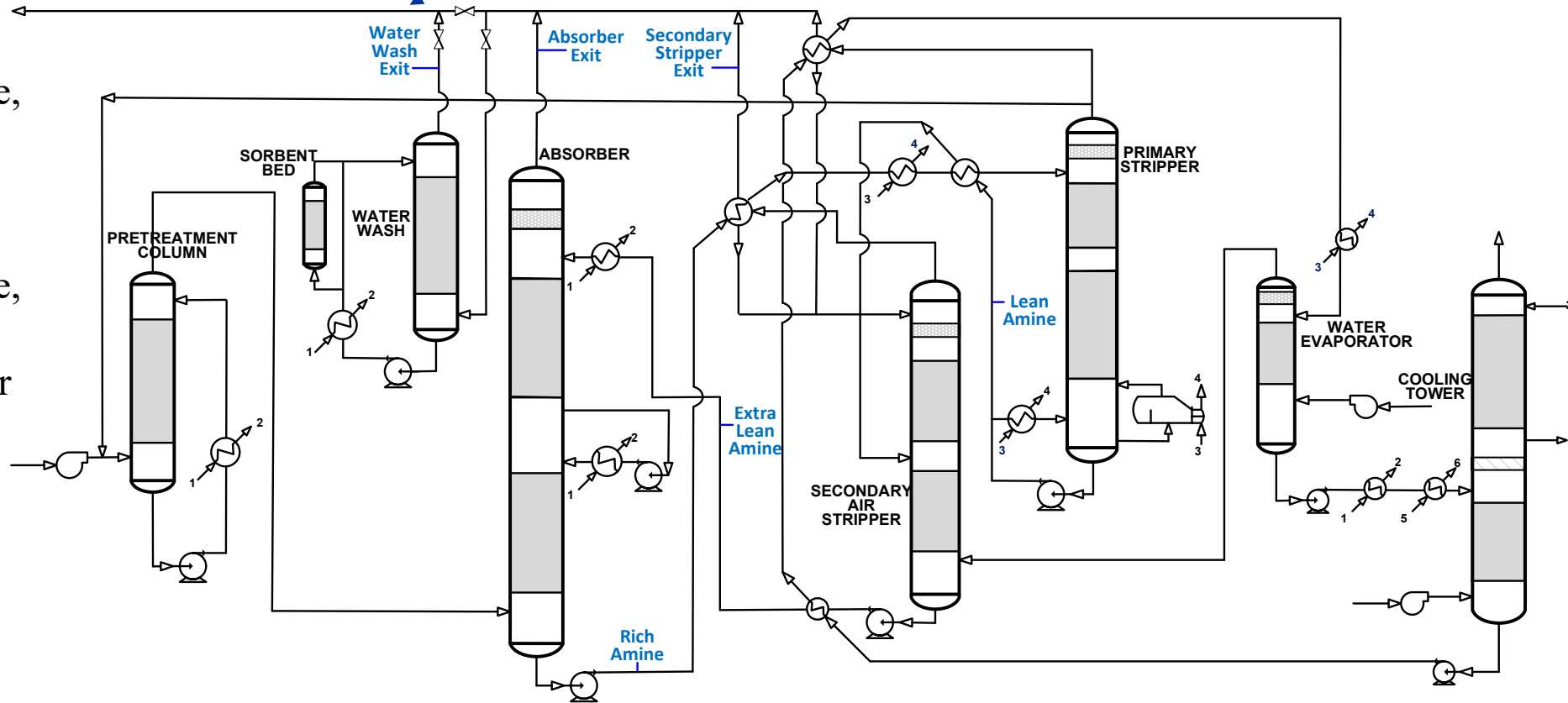


<https://www.research.uky.edu/news/uk-nucor-steel-gallatin-partnering-unique-co2-capture-project>

Emission Sampling Locations

- ❑ Sampling done during MEA campaign at absorber outlet:
 - UKy (isokinetic method and for amine, ammonia, aldehyde, nitrosamines)
 - EPRI (isokinetic method and for amine, ammonia, aldehyde)
 - UTA (in situ FTIR for amine, ammonia)
- ❑ Water wash installed in 2019 with outlet sampling done by UKy
- ❑ EPA and CTM sampling and analysis methods applied

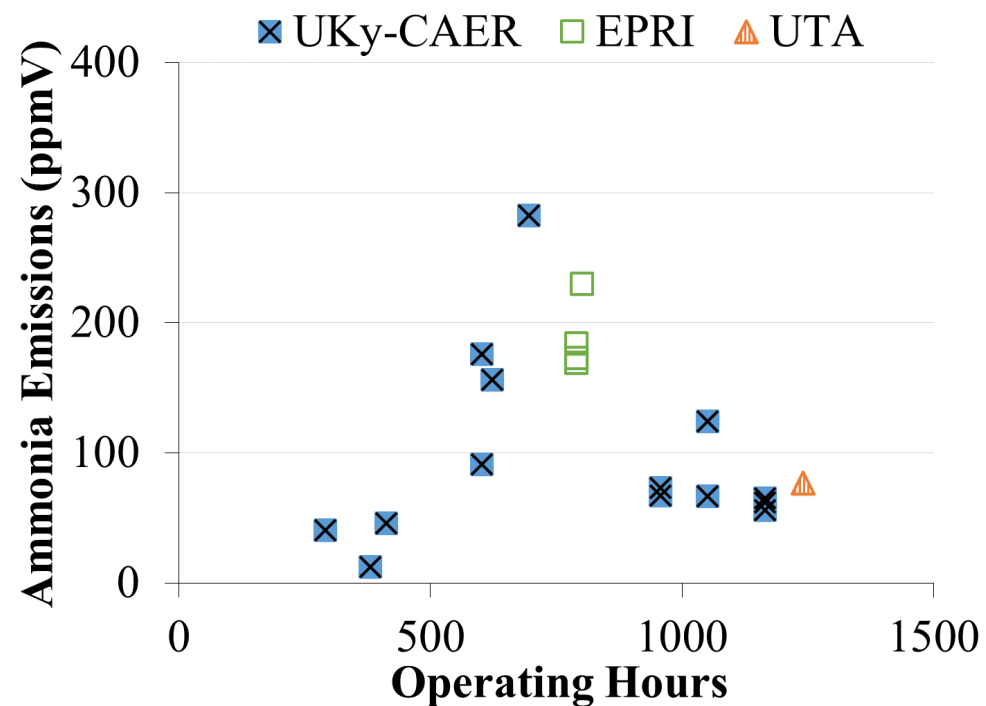
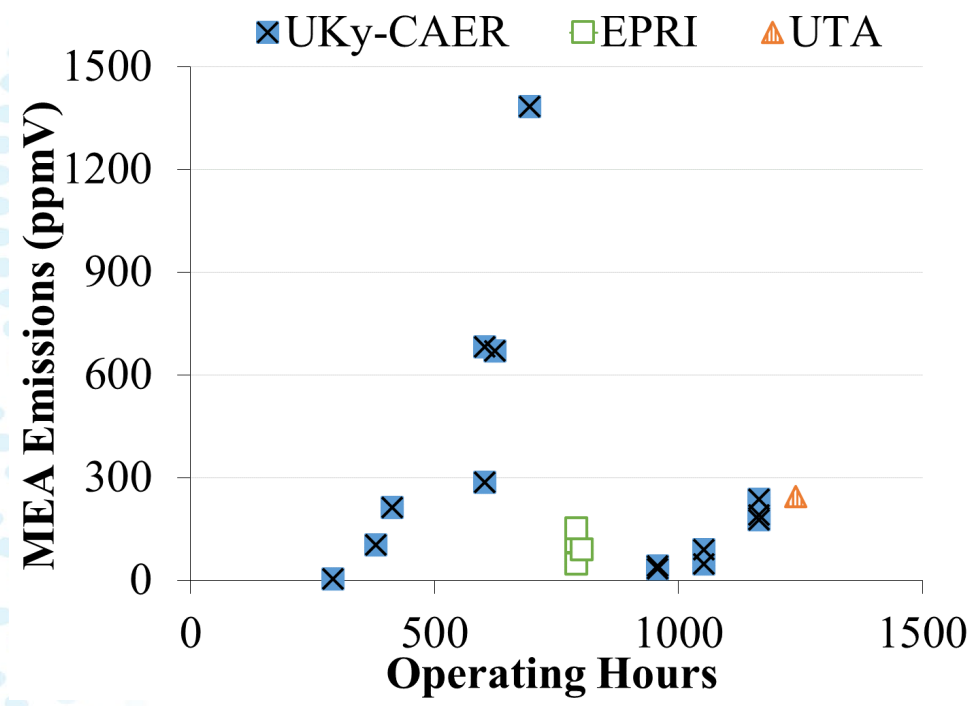
No Nitrosamines
 <1 ppmV Total Amine



1: COOLING WATER SUPPLY, 2: COOLING WATER RETURN, 3: STEAM SUPPLY, 4: CONDENSATE RETURN, 5: CHILLED WATER SUPPLY, 6: CHILLED WATER RETURN

15 TPD CCS Unit Emissions Results

- At absorber outlet, prior to water wash
- No nitrosamines identified above LOQ
- 8 specific nitrosamines investigated with LOQs of 1.3 to 9.3 ppb

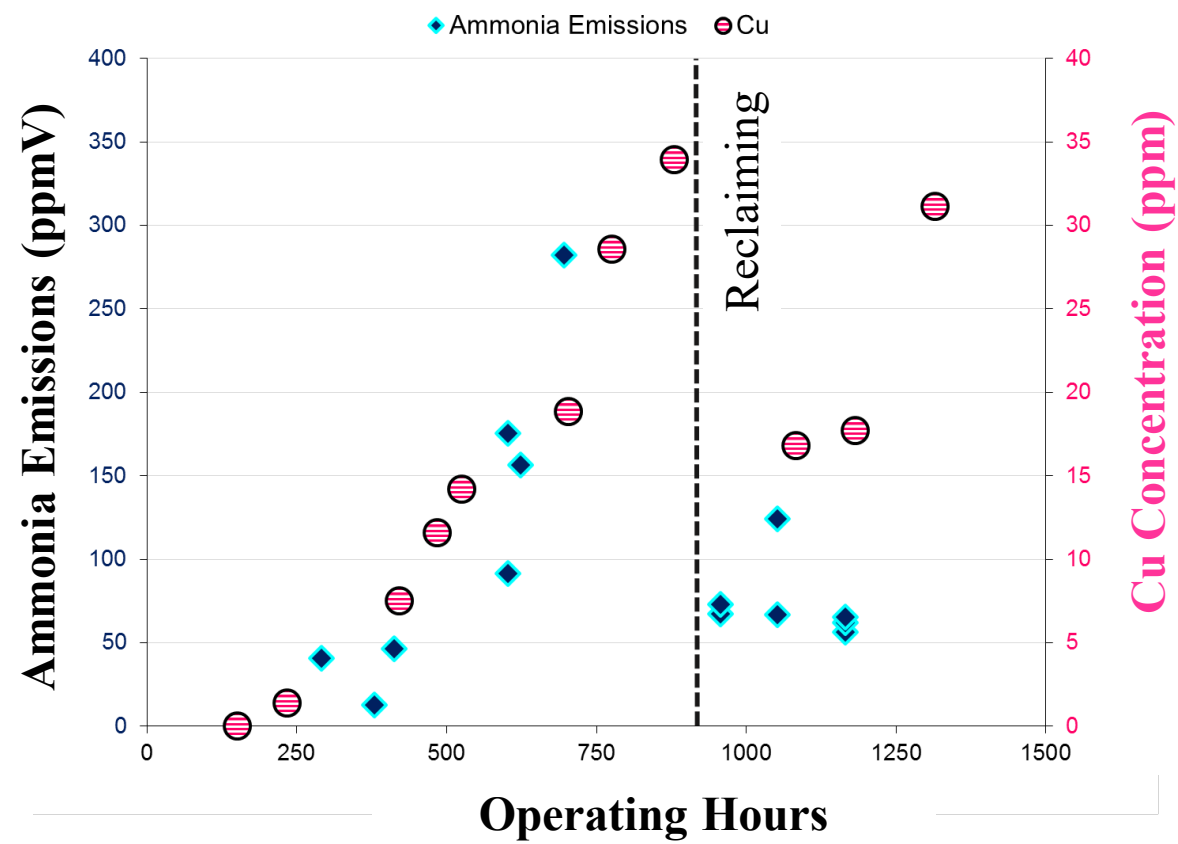
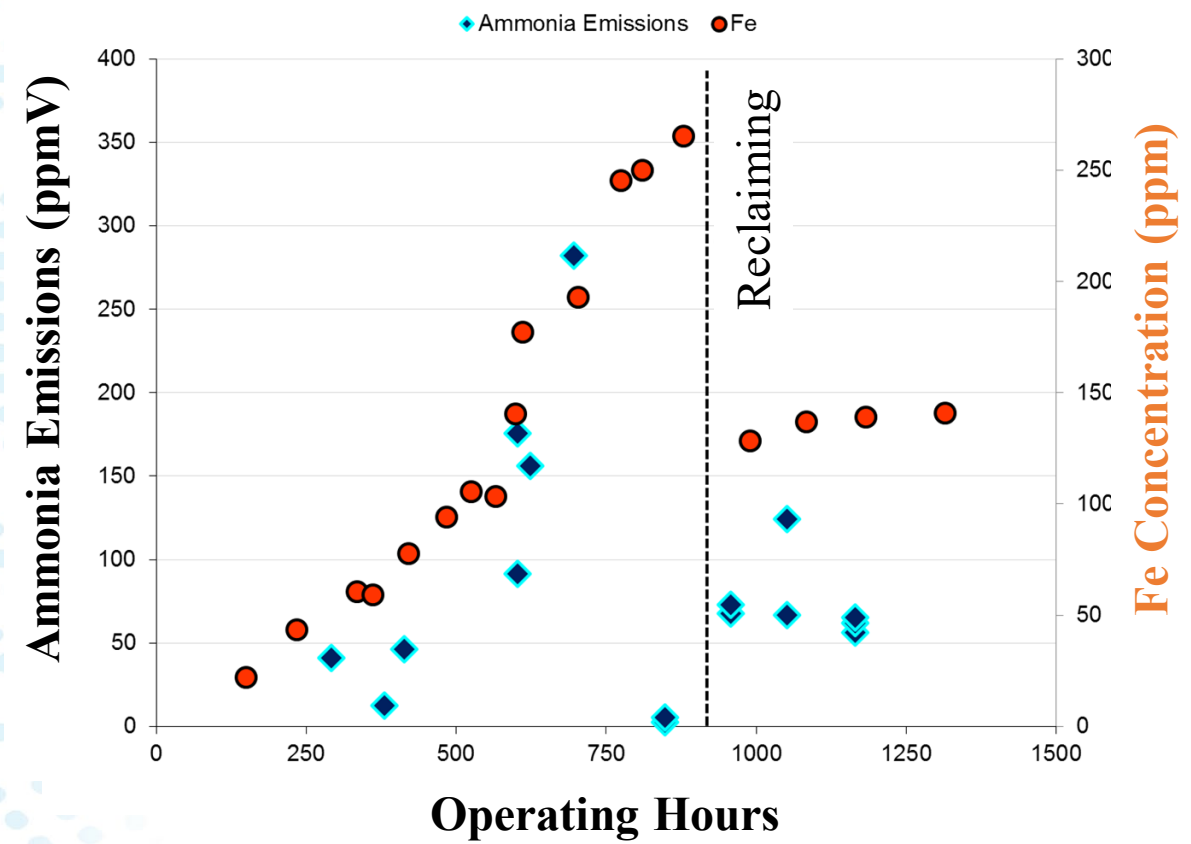


Total Aldehyde:
 <900 ppb (UKy)
 <300 ppb (EPRI)
 Formaldehyde,
 Acetaldehyde and
 Propionaldehyde (<LOD)

Total Keytone:
 <800 ppb (UKy)
 < 350 ppb (EPRI)
 Acetone, Isophorone and
 Acetophenone (<LOD)

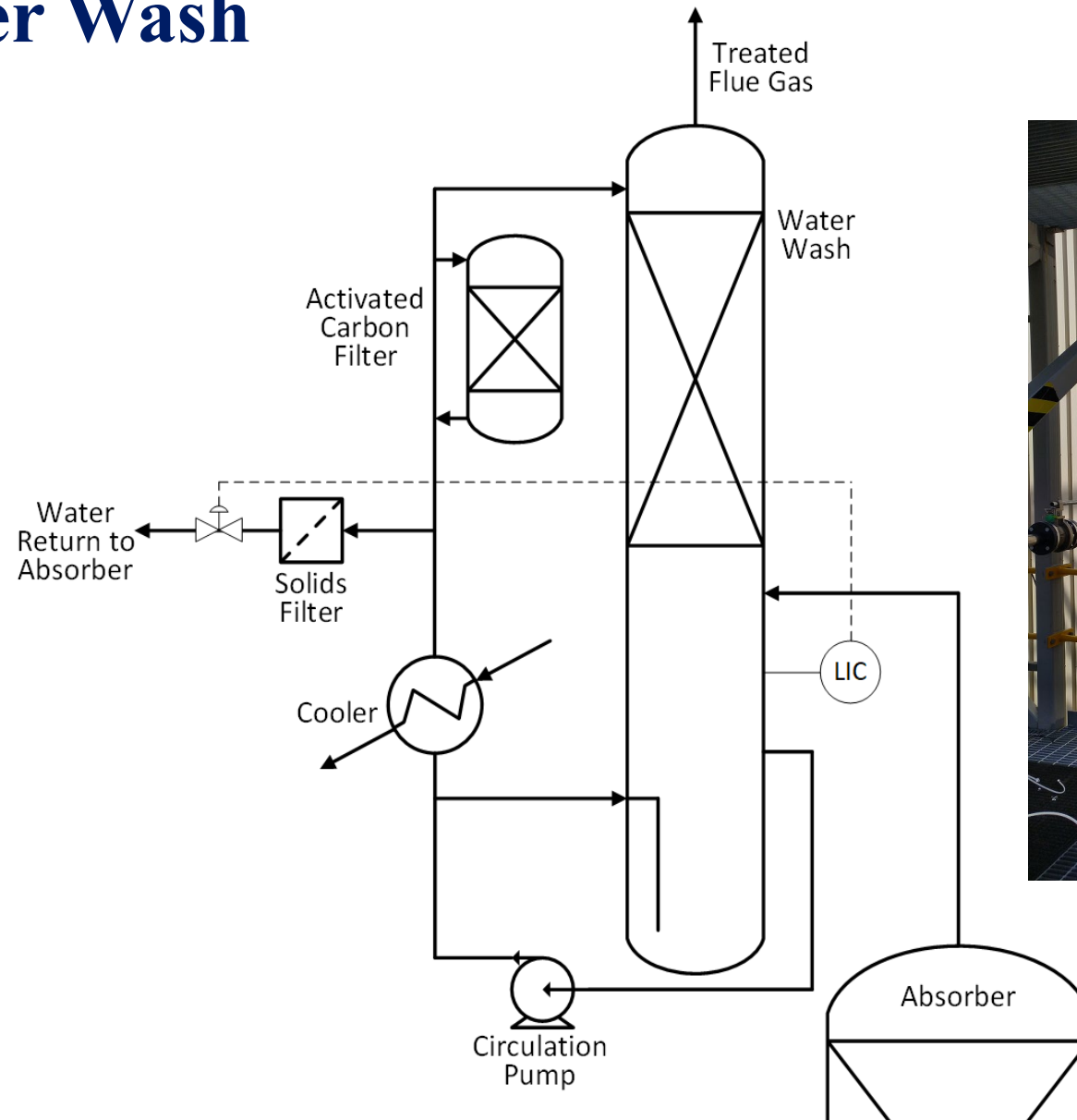
15 TPD CCS Unit Emissions Results

- At absorber outlet, prior to water wash
- Ammonia emissions directly related to solvent Fe and Cu concentrations

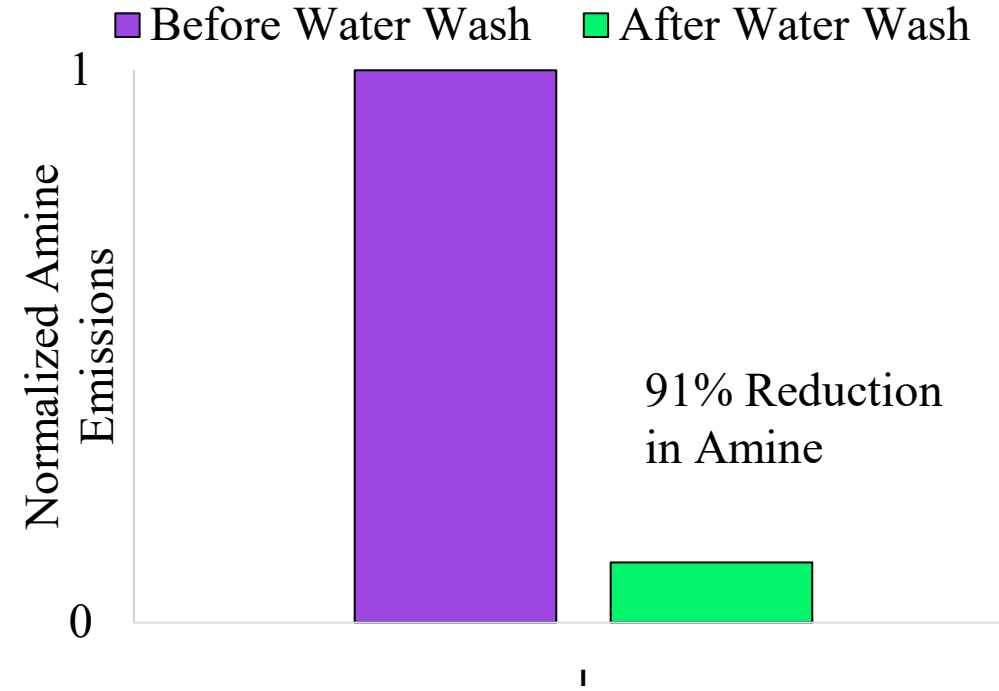
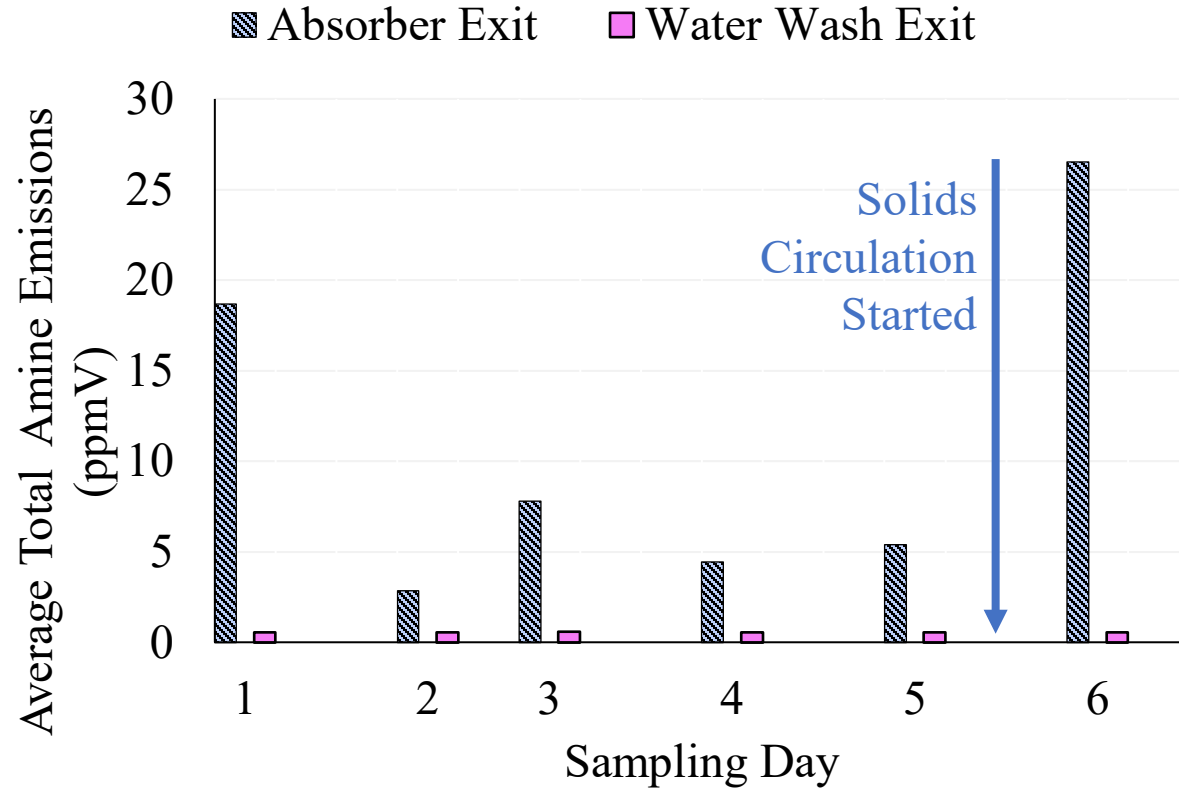


UKy Pilot Water Wash

- ❑ Installed in 2019
- ❑ Solids assisted UKy technology
- ❑ <1 ppm total amine demonstrated

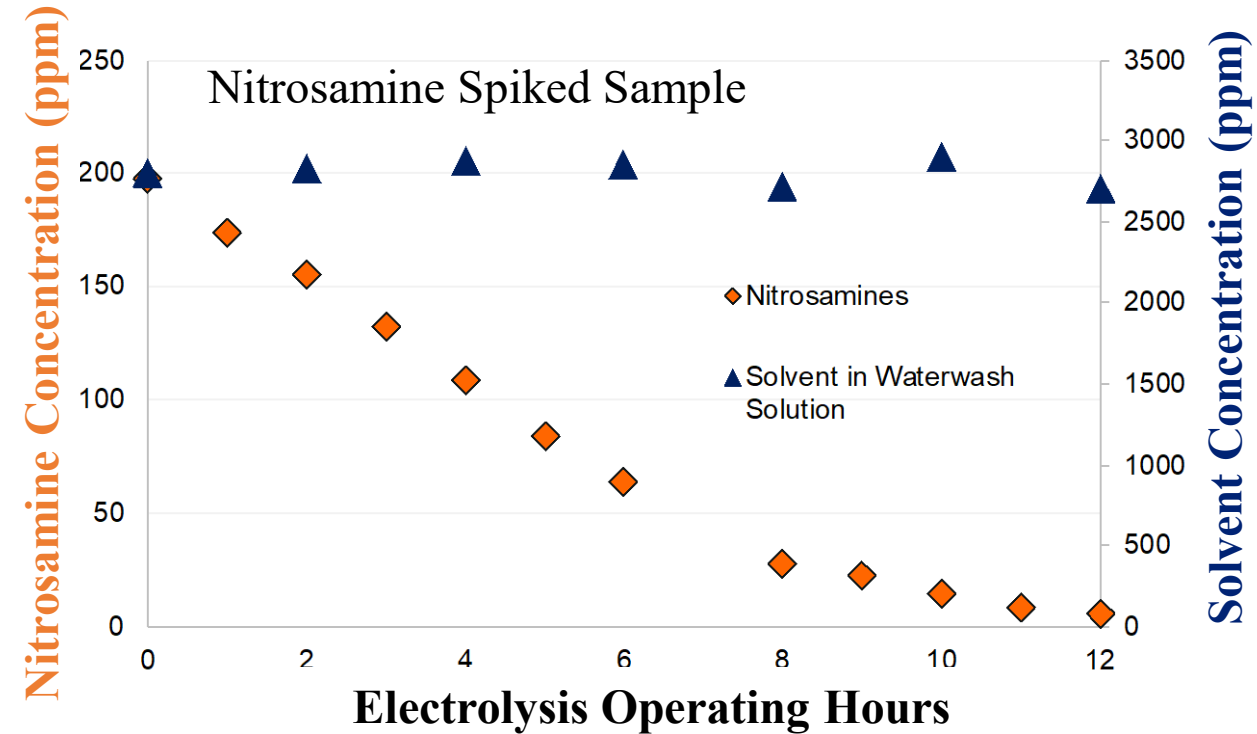
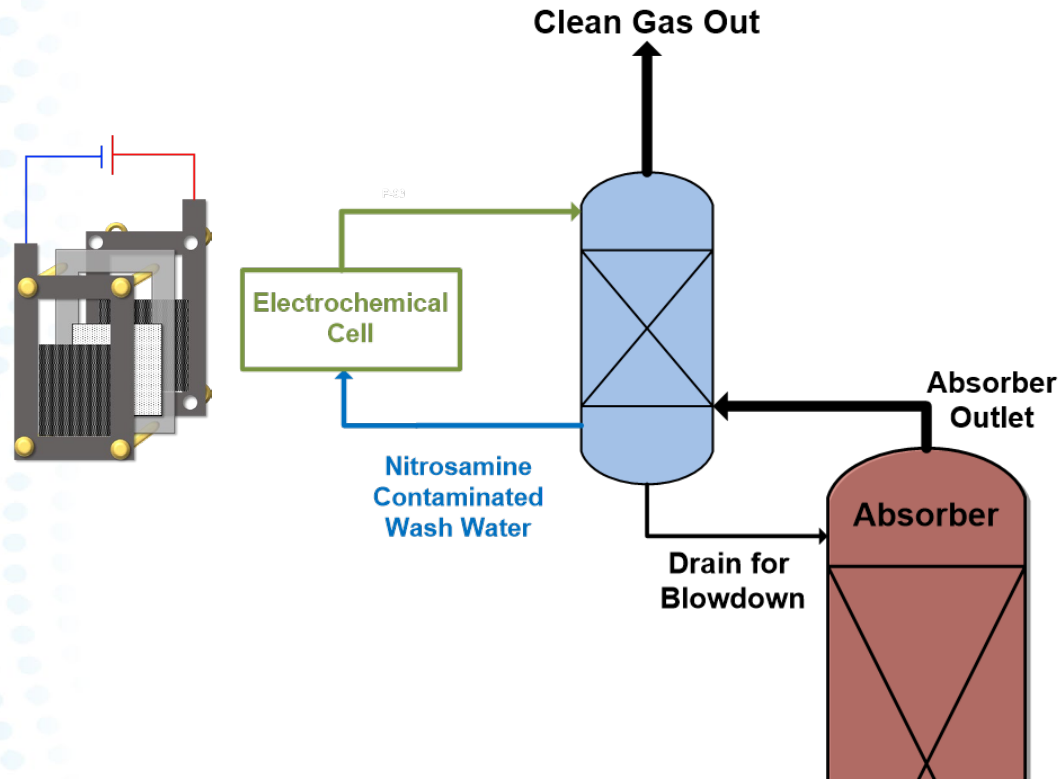


UKy Pilot Water Wash



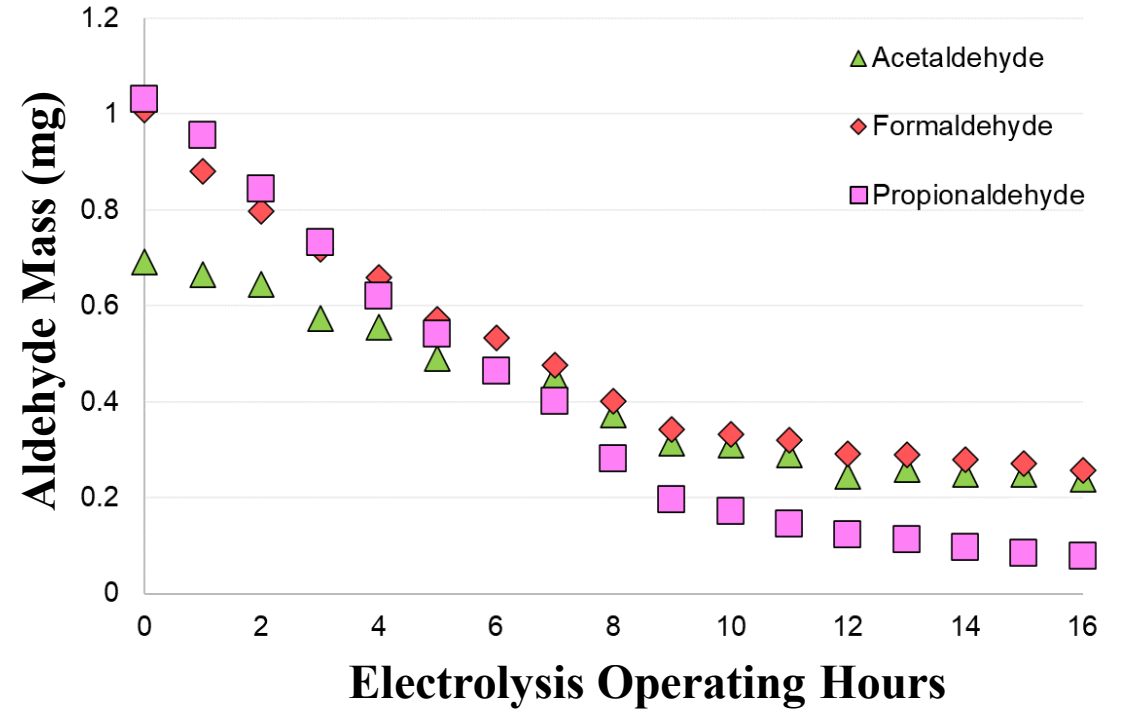
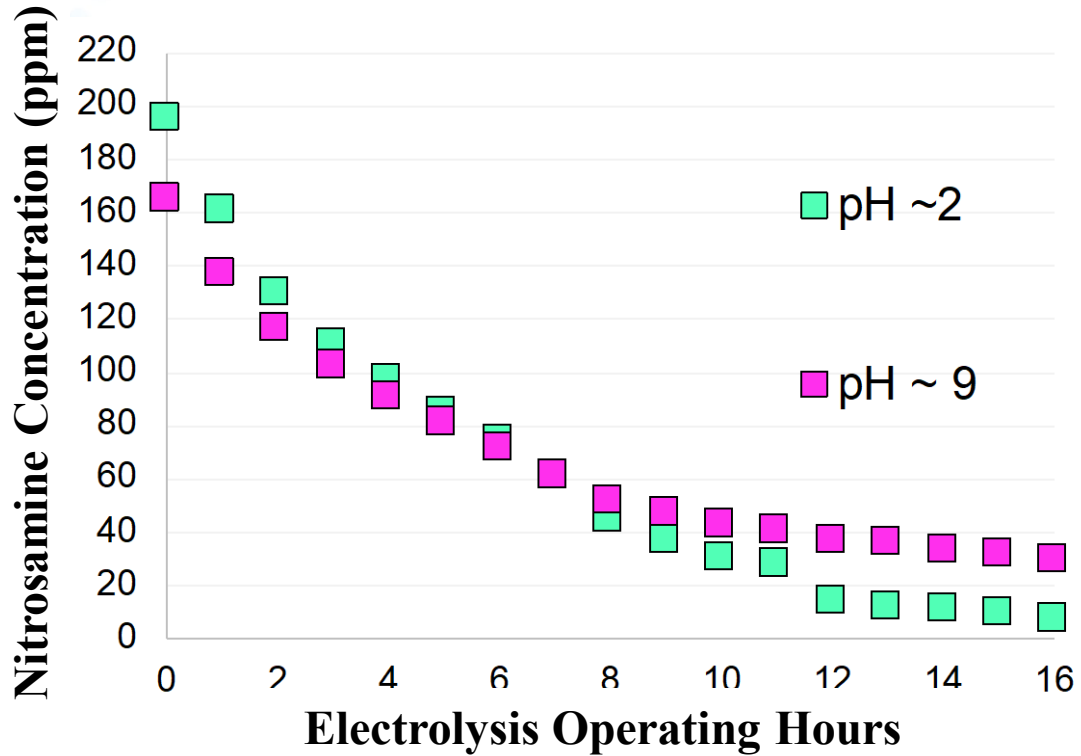
□ <1 ppm total amine demonstrated

UKy Nitrosamine Destruction Technology



- Electrochemical cell operates with no matrix effects, 90-99% removal to below LOD
- Degradation reaction is electrochemical reduction of the nitrosamine back to the parent amine
- The electrochemical process is beneficial as it does not decompose the solvent in the water wash
- Not preferential to any one nitrosamine structure

UKy Nitrosamine Destruction Technology



- Efficient at decomposing nitrosamines in both water wash and acid wash conditions
- Can be adapted to decompose aldehydes with further optimization

Read More

- Thompson, Combs, Abad, Bhatnagar, Pelgen, Beaudry, Rochelle, Hume, Link, Figueroa, Nikolic and Liu. Pilot Testing of a Heat Integrated 0.7 MWe CO₂ Capture System with Two-stage Air-stripping: Emission. *International Journal of Greenhouse Gas Control*. 64 (2017) 267-275
- Thompson, Bhatnagar, Combs, Abad, Onneweer, Pelgen, Link, Figueroa, Nikolic and Liu. Pilot Testing of a Heat Integrated 0.7 MWe CO₂ Capture System with Two-stage Air-stripping: Amine Degradation and Metal Accumulation. *International Journal of Greenhouse Gas Control*. 64 (2017) 22-33
- Li, Landon, Irvin, Zheng, Ruh, Kong, Pelgen, Link, Figueroa, Thompson, Nikolic and Liu. Use of Carbon Steel for Construction of Post-combustion CO₂ Capture Facilities: A Pilot-scale Corrosion Study. *Industrial & Engineering Chemistry Research*. 56 (2017) 4792-4803.

Acknowledgements

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