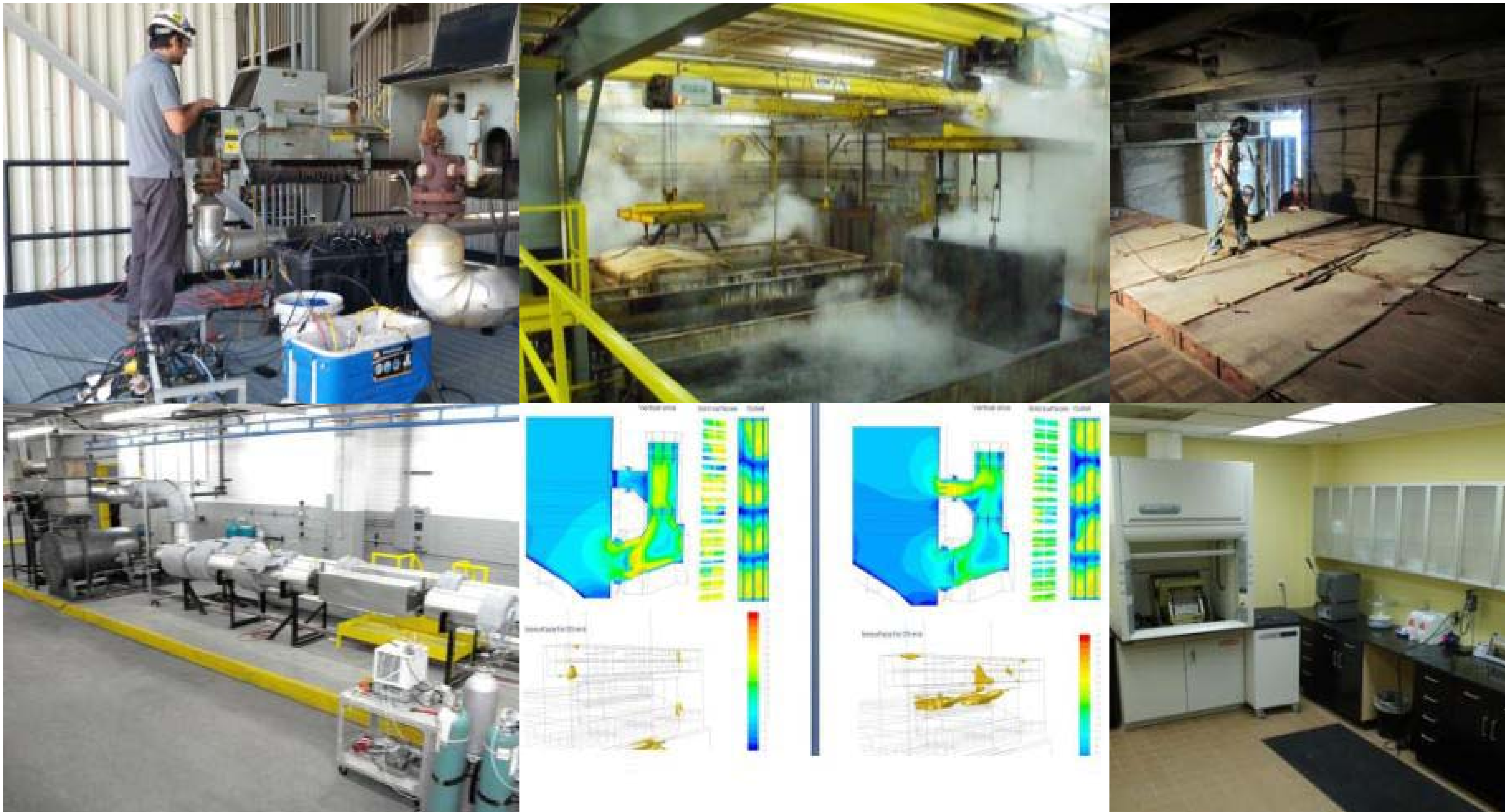


McIlvaine
NOx Reduction Innovations for Coal Fired Plants

Mark Ehrnschwender
November 6th, 2014

steag

STEAG Group

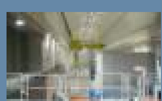
STEAG GmbH

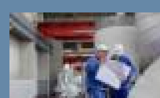



Power Operations and Engineering Services

Power O&M services Worldwide
Operations in India, Spain, Brazil, Colombia, Philippines, etc.
Ownership & Operations of solar, wind, fossil fuel, natural gas, biogas and geothermal
Over 20,000 MW's of operation worldwide

STEAG Energy Services GmbH

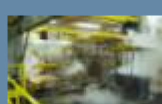


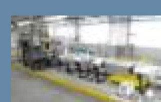



Engineering and Consulting Services

Complete Plant Integration Services
Owners A/E Services
Operations in Europe, India, Turkey, South Africa and the US

STEAG Energy Services LLC



Engineering and Consulting Services (USA)

Worldwide STEAG group NOx Expert
HQ and Plants in NC - Offices in PA, IL, DC
500,000 ft^2 of warehouse space
60,000 m^3 regenerated, 4,000 XRF's annually,
2 x 2013 VGB certified bench scale reactors

“The Basics”
The SCR Catalyst / Reactor

Catalyst Oxidation Reactions

- **NOx Reaction - $NH_3 + NO\ (NO_2) \rightarrow H_2O + N_2$**
- **SOx Reaction – $SO_2 + O_2 \rightarrow SO_3$**
- **Mercury Reaction – $Hg + O_2 \rightarrow HgO$**

Where / When do the reactions occur?

- **NOx Reaction – Quick Reaction**
- **SOx Reaction – Slow Reaction**
- **Mercury Reaction – Quick Reaction – NO_X is preferential**

What is STEAG Doing on it’s Units for Mercury

- **Primary Mercury oxidation is layer**
- **Secondary is Bromide Addition**
- **Re-emission is by PAC into the FGD Unit**



"The Basics"
Catalyst Regeneration

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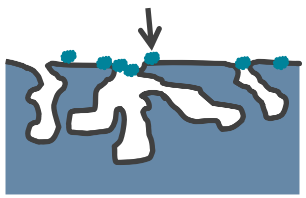
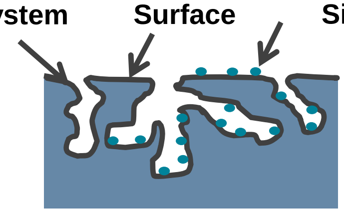
- **Chemically removing De-activating compounds**



i.e. Fly Ash

i.e. Calcium, Magnesium



i.e. Arsenic, Phosphorus, Sodium, Potassium

PRB

- **Removal of Chemicals and Ions from Catalyst**
- **Addition of the activating compound (Vanadium) and strength metals (Tungsten or Molybdenum) back onto the catalyst**

"The Basics"
Longevity of Catalyst

- **STEAG has catalyst that has been regenerated 7 time (26 years in operation)**
- **What should a customer buy?**

	Honeycomb	Plate
Wall Thickness	> 0.8 mm	> 0.7 mm
Tungsten or Molybdenum	>7%	
Metal Substrate	N/A	Austenitic Stainless

- **Anything less will lead to throw away catalyst!**
- **Catalyst Disposal Issues:**
  - **Ash disposed of as non-hazardous (40 CFR)**
  - **Ceramic Material Non-hazardous**
  - **Metal recycled. China working on ceramic recycle**
  - **Future CCP could affect this!**

Innovation:
Co-coupling of SCR & SNCR

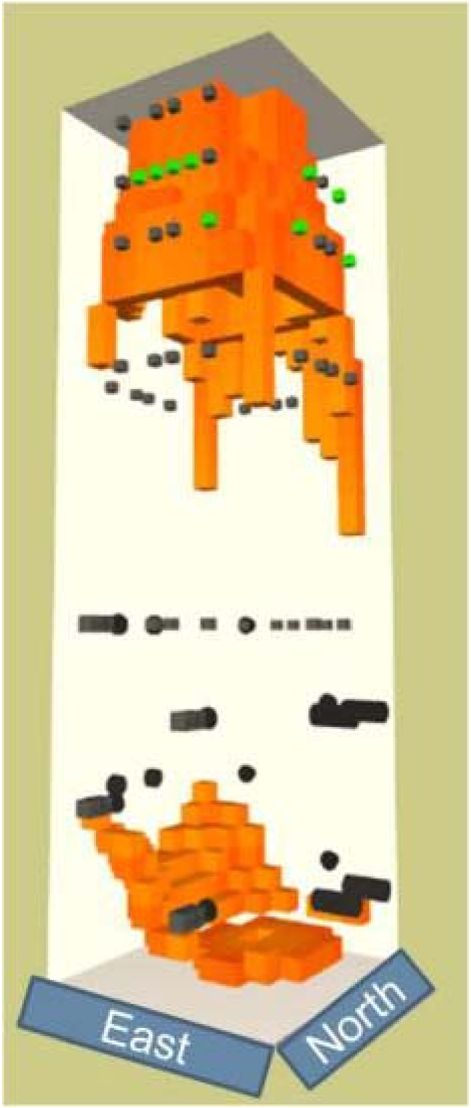
STEAG is working on Strategy on STEAG units for co-coupling of SNCR with SCR.

- **Need for additional removal on STEAG units 60% to 80% or 80% to 90%.**

	Case 1: Stretching the SCR			Case 2: Stretching the SCR		
	No SNCR	Typical SNCR	STEAG Approach	No SNCR	Typical SNCR	STEAG Approach
Boiler Inlet	250	250	250	250	250	250
SNCR Reduction	0%	25%	50%	0%	25%	50%
SCR Inlet	250	188	125	250	188	125
SCR reduction	60%	60%	60%	80%	80%	80%
NOx Outlet	100	75	50	50	38	25
Total Reduction	60%	70%	80%	80%	85%	90%

How to achieve 50% reduction with SNCR?

- **More injectors**
- **Live CFD modeling (STEAG Powitec System)**



Innovation:
In-situ Dry Cleaning in the Reactor

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United States Patent No 8,268,743 B2

Removal Systems	Benefits	Challenges
Vacuuming	Large ash removal	Top ash only
Air Lancing	Mechanical/light ash removal	Only 4-6 inches of pluggage removal
Mechanical Shakers	Large ash removal	On-site plate removal Honeycomb "verboten"
Reactor Shakers	Large ash removal	Unknown long-tern reactor effects
Scraping / Poking	Mechanical/light ash removal	Damages the catalyst surface – Logs normally need to be replaced before regeneration
High Pressure Wash	Large ash removal	Water reacts with SO_3 to form sulfuric acid, which deteriorates the metal substrate in plate, solidifies any remaining ash and releases iron oxide in ash to increase SO_2/SO_3 conversion rate
Dry Ice Blasting	**Mechanical cleaning for all types of catalyst**	**Unable to undo damages caused by other cleaning techniques**

Before After

- **Most effective and very safe cleaning method**
- **Our process has reduced pluggage from 100% down to < 5%**
- **Savings in Pressure Drop alone provides 6 to 8 month payback**
- **Successful performed on all Catalyst Types**

Innovation:
Regeneration & Mercury

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- **Catalyst Re-calcination**
  - **Heat treatment above 800 ºF but below 850 ºF**
  - **Time is 9 to 12 hours**
  - **Regain strength, bond material and eliminate inherent water**
- **Single Impregnation of Vanadium (activating compound) with tungsten or molybdenum (strength metals)**
- **Mercury Testing**
  - **STEAG has acquired the testing facility from Martin Luther University (Halle-Wittenberg) – Research before 2002**
  - **STEAG continues the work and has several testing contracts**
- **What is STEAG doing on it's Units for Mercury**
  - **Primary Strategy - Mercury oxidation is lower layer of catalyst**
  - **Secondary Strategy – Trim with Bromide Addition**
  - **Capture Oxidized Mercury in the wFGD with Re-emission is by PAC into the FGD Unit**
  - **STEAG has Patented Mercury removal technology for wFGD water**

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