REINHOLD ENVIRONMENTAL Ltd.

2013 APC Round Table
& Expo Presentation

July 8-9, 2013, in St. Louis, MO / Hosted by Ameren

Re-Emissions Drivers & Options

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July 9th, 2013

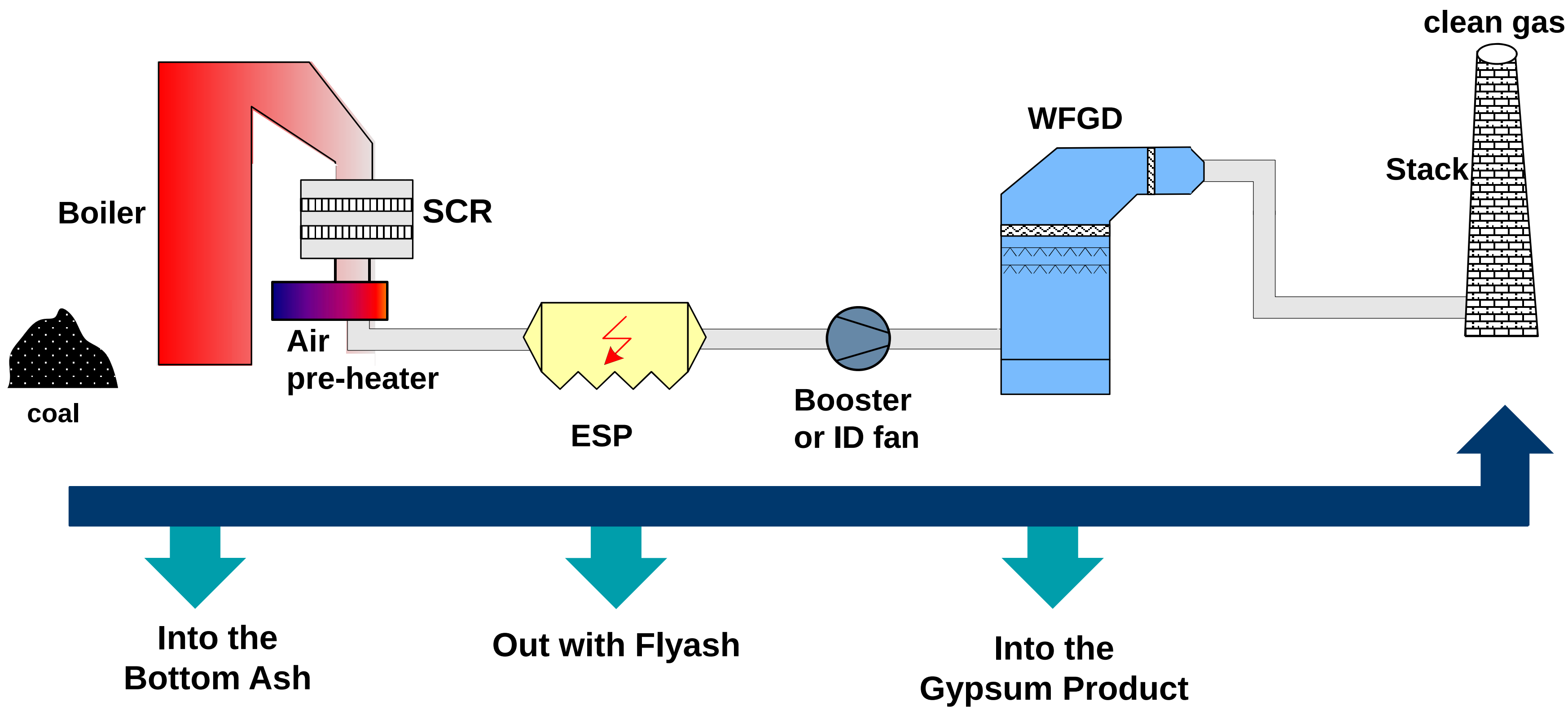
Mercury Regulations

- ## Mercury and Air Toxics Standards (MATS)
  - EPA finalized the Mercury and Air Toxics Standards (MATS) rule in December 2011, covering mercury and hazardous air pollutants (HAPs) like selenium, arsenic and others
  - Existing coal- and natural gas-fired plants face a compliance date of April 2015, with a 'broadly available' one-year extension
  - First time mercury has been regulated at a national level for power plants, although ~16 states were already phasing in limits roughly similar to MATS

	Filterable PM[a]	HCl[b]	SO_2[c]	Mercury
Existing units (higher grade coals)	$3*10^{-2}$ lb/MMBtu (~45 mg/Nm^3)	$2*10^{-3}$ lb/MMBtu (~3 mg/Nm^3)	0.20 lb/MMBtu (~300 mg/Nm^3)	1.2 lb/TBtu (~1.8 ug/Nm^3)
Existing units (lignite)	$3*10^{-2}$ lb/MMBtu (~45 mg/Nm^3)	$2*10^{-3}$ lb/MMBtu (~3 mg/Nm^3)	0.20 lb/MMBtu (~300 mg/Nm^3)	4.0 lb/TBtu (6 mg/Nm^3)

[a]Surrogate for non-mercury HAP metals
[b]Surrogate for acid gas HAP
[c]Surrogate for acid gas HAP for plants operating FGDs

What is the fate of the Mercury?

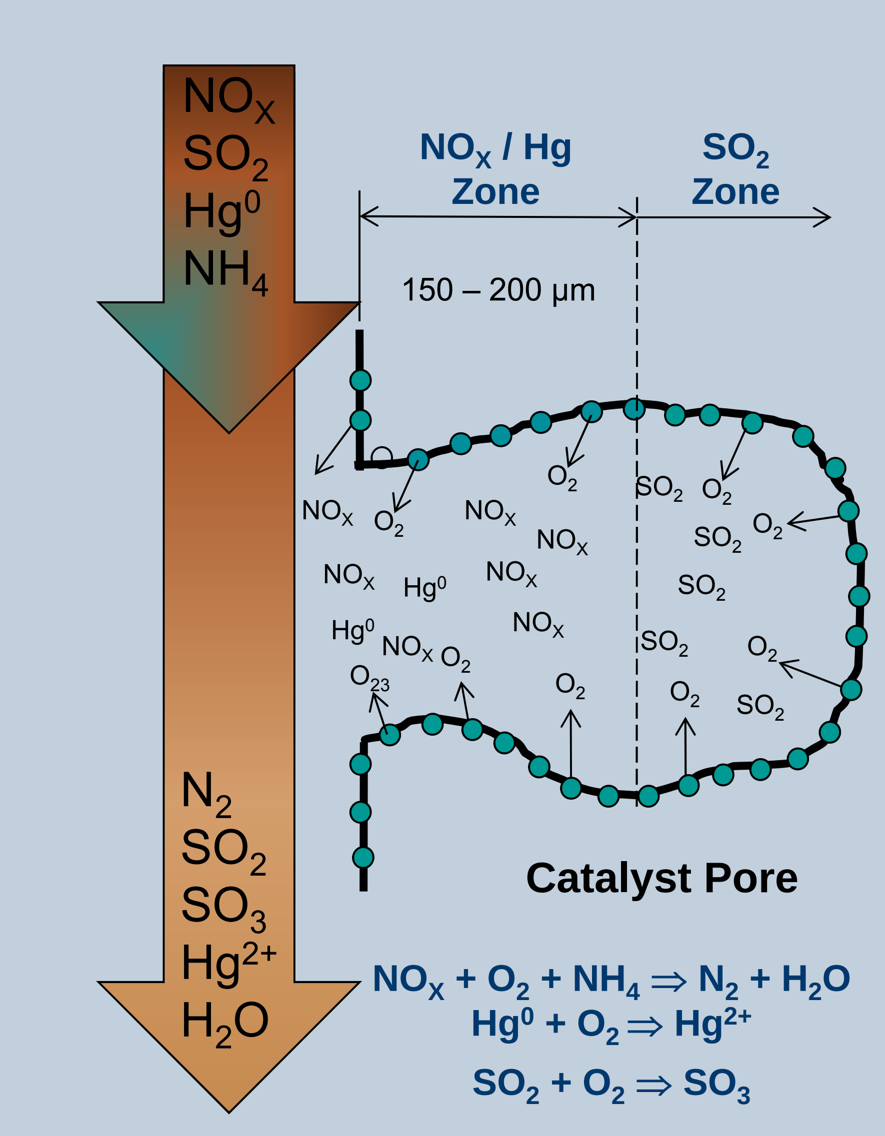


Combustion Mercury Oxidation

- Oxidation ocurring during combustion
  - Formation of Mercury Oxide in the Furnace: $2\,Hg + O_2 \rightleftarrows 2\,HgO$
  - Formation of Elemental Chlorine in the Furnace: $4\,HCl + O_2 \rightleftarrows 2\,H_2O + 2\,Cl_2$
  - Oxidation of Mercury: $Hg + Cl_2 \rightleftarrows HgCl_2$
- These reactions are important for the oxidation of elemental mercury in the furnace and boiler, the generation of Cl_2 and subsequent formation of ionic mercury.
- Eastern fuels contain high levels of chloride resulting in greater levels of Mercury oxidation.

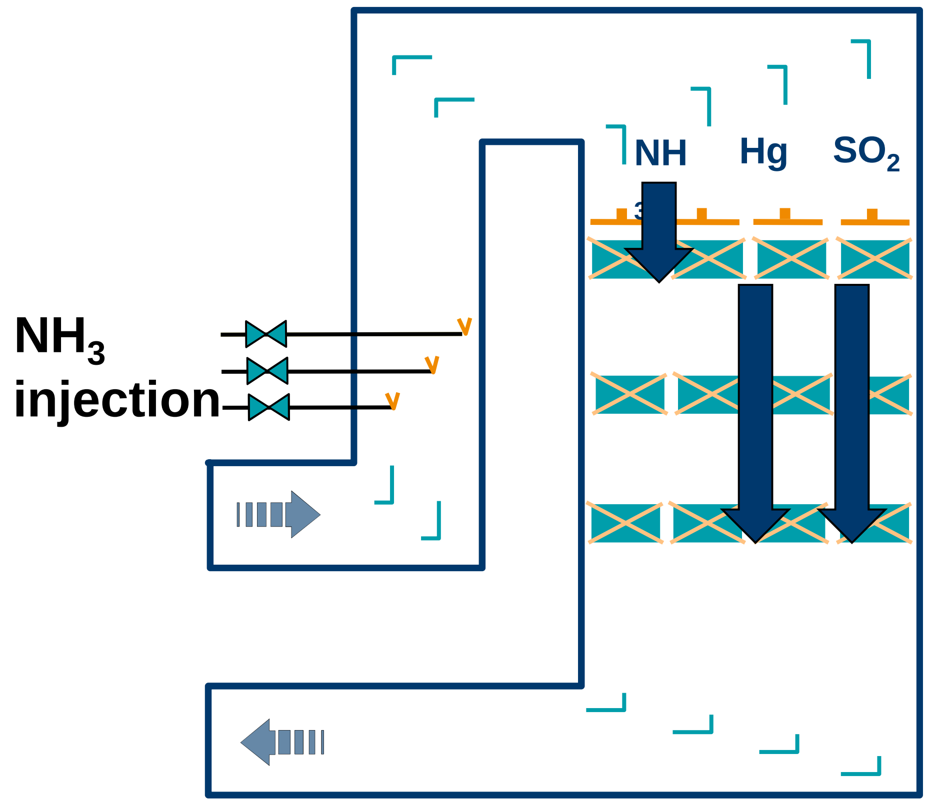
Mercury Oxidation in the SCR

- The Vanadium Pentoxide (V_2O_5) releases oxygen (O_2)
- The fluegas stream contains the following constiuents; Nitrous Oxide (NO or NO_2), Sulfur Dioxide (SO_2) and Mercury (Hg) which compete for the oxygen.
- The preference for the oxygen is;
  - 1st - Nitrogen,
  - 2nd – Sulfur Dioxide
  - 3rd - Mercury
- The presence of Ammonia (for the NOx reaction) inhibits the Mercury reaction.



The SCR
Mercury Oxidation Component

- **Ammonia will surpress mercury oxidation.**
- **Reactor with a significant reactor Potential**
- **Results:**
  - Ammonia is consumed in the top layer.
  - Lower 2 elevations will produce the oxygen for Mercury Oxidations (also SO_2 to SO_3 conversion rate)



High Levels of Mercury Oxidation

The SCR
Mercury Oxidation Component

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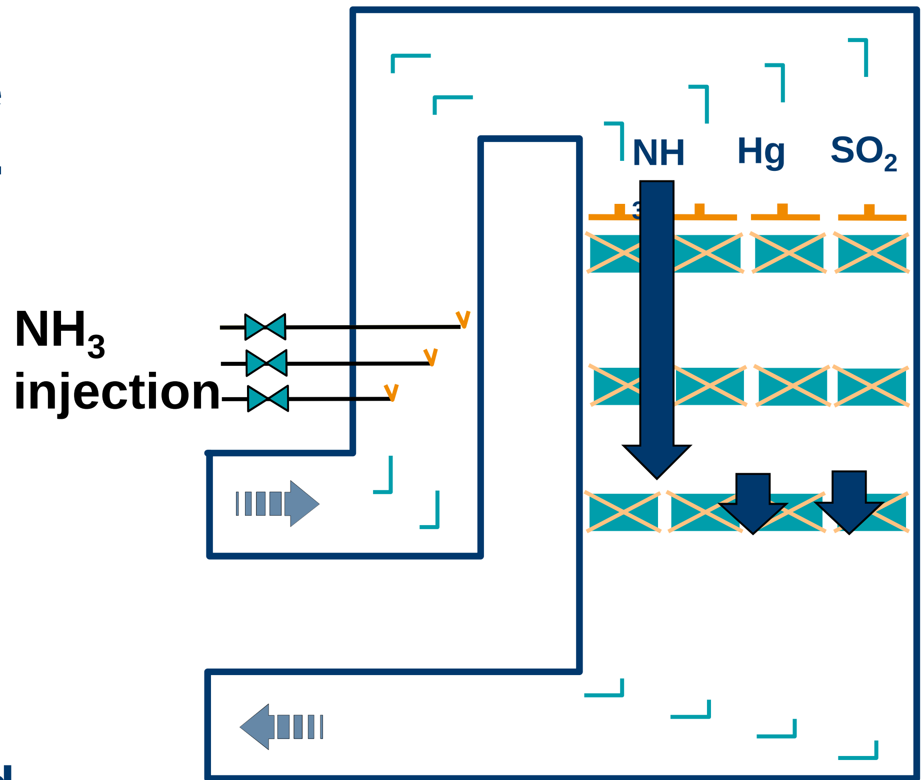
- **As the catalyst in the SCR de-activates, more catalyst surface is needed for the NO_X reactions.**
- **Results:**
  - Ammonia consumption for NOx removal takes most of the catalyst surface.
  - Lower catalyst level is the only effective surface for Mercury (also SO_2 to SO_3 conversion rate).
- **If combustion / SCR is the only strategy for Mercury oxidation, catalyst replacements may need to be more frequent.**

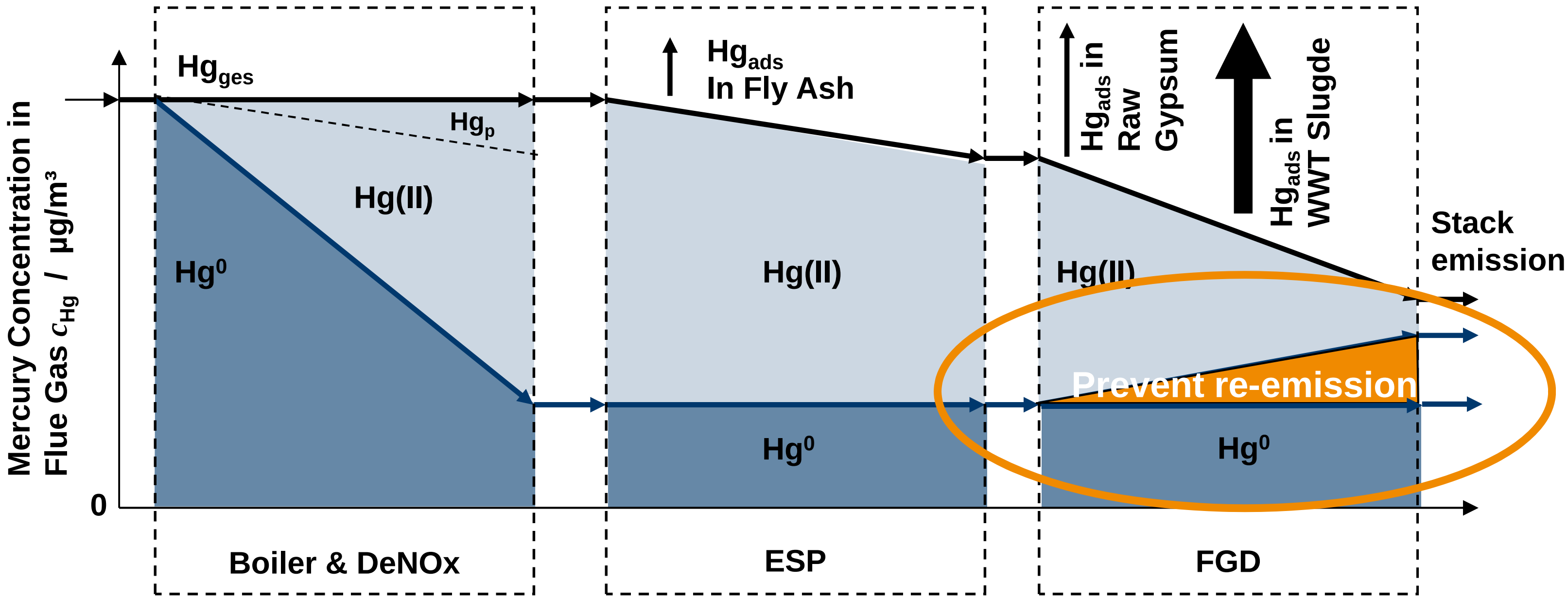


Low Levels of Mercury Oxidation

What else can be done to enhance Mercury Oxidation?

- **Chlorine promotes the Mercury Oxidation.**
- **Chlorine is a halogen, Other Halogens will work**
  - **Fluorine (F_2)**
  - **Chlorine (Cl_2)**
  - **Bromine (Br_2)**
  - **Iodine (I_2)**
  - **Astatine (At_2)**
- **Chlorine is a halogen, Other Halogens will work.**
- **Most popular is Bromine as Calcium Bromide (Nalco / Volsteen) & Ammonium Chloride (CBI)**
- **STEAG strategy for Mercury oxidation is a combination of:**
  - **Natural Combustion Oxidation**
  - **SCR Oxidation**
  - **Trim mechanism - Calcium Bromide Addition to the fuel**

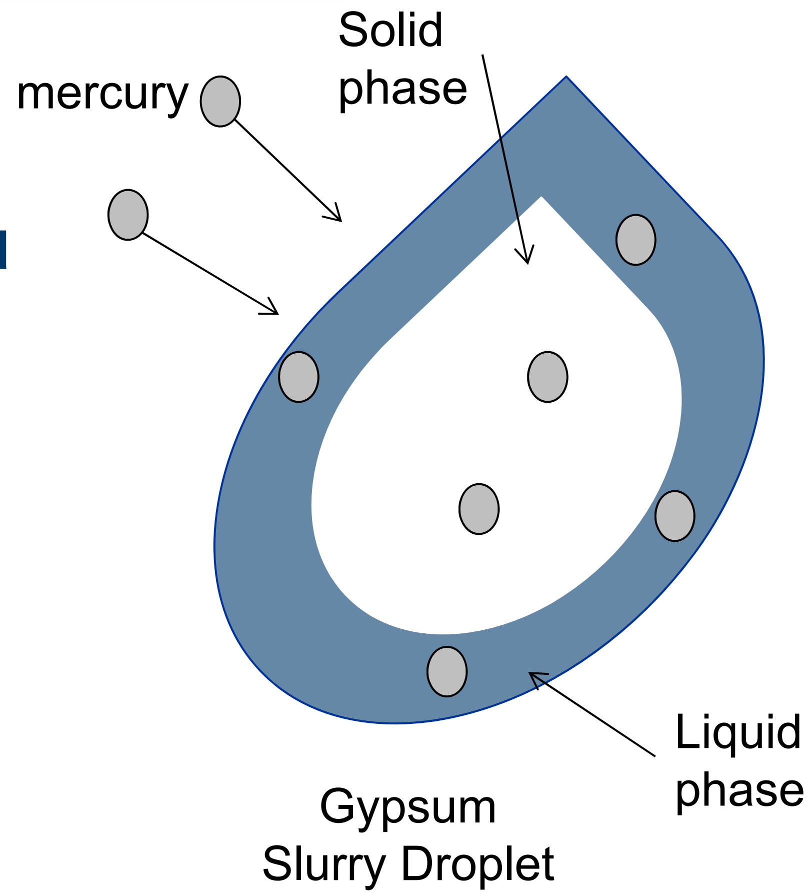
Mercury in the Wet FGD System



- Mercury in oxidized form is very soluable.
- Elemental Mercury passes through the wet FGD system.
- A “switching” of mercury back to elemental can occur – The mercury is thus released – Re-emissions

Mercury capture in the wet FGD

- The wet FGD highly efficient at capturing oxidized Mercury.
- The mercury moves into the solid part of the particle remains captured.
- The liquid phase mercury is “valnerable” to the re-emissions.
- The focus of re-emissions technologies is to prevent the mercury from shifting back to elemental Mercury.



Re-Emission Technology Strategies

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thebabcock&wilcoxcompany

Absorption Plus™

NALCO
An Ecolab Company

MerControl 8034

Novinda

Amended Silicates

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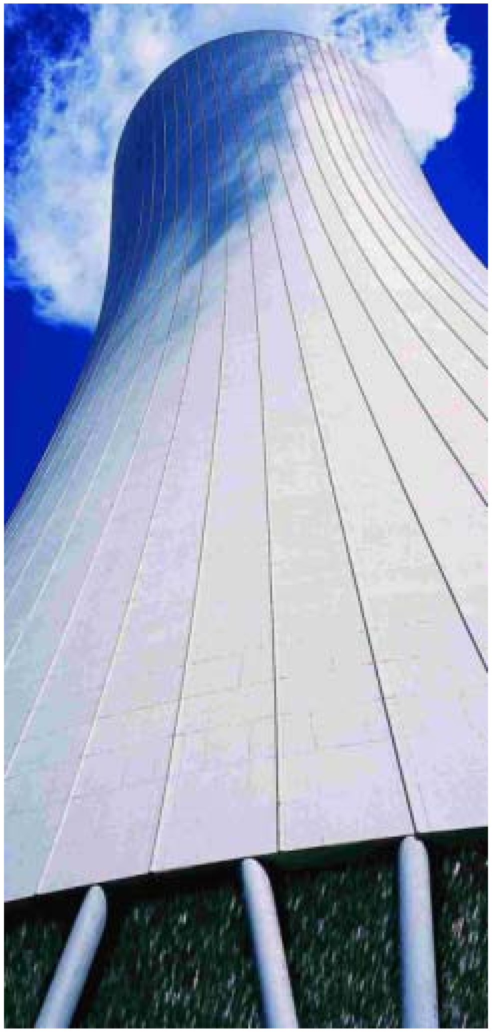
Powder Activated Carbon

The STEAG Mercury Approach

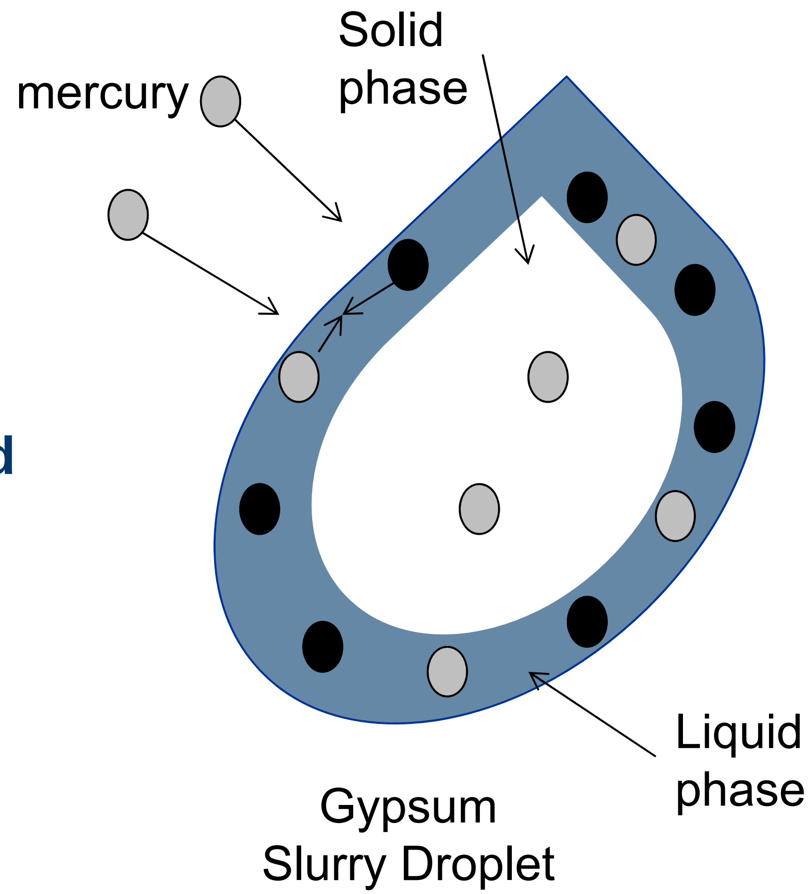
- **This is a 2 Phase Approach**
  - **Phase 1 - <u>Oxidized</u> Mercury captured in a wet FGD system**
  - **Phase 2 – Disposition of the Mercury. There are several options.**

- **STEAG Approach Requirements**
  - **The Mercury <u>must</u> be in the oxidized state (Hg2+)**
  - **Wet FGD System**
  - **Power Activated Carbon (PAC) is added to Wet FGD System**
  - **Mercury can be removed from the process by:**
    - Mercury in the gypsum/dewatered solids
    - Mercury into the waste water filter press
    - Mercury / metals reduced and then removed from system



How is the Mercury Sequestered?

- **STEAG adds carbon to the liquid phase of the droplet.**
- **The mercury the moves into the solid part of the particle remains captured.**
- **The mercury / carbon in the liquid phase is the important mercury capture.**
- **Once the mercury bonds to the carbon it cannot convert back to elemental state.**



Utilization of PAC in a Wet FGD

Dosing Systems:

- Dosing is dependant upon PAC Requirements
- Gravity influenced and reliable dosing of PAC from Super Sacks
- Injection of PAC upstream of FGD recycle pump
- PAC consumption depends on FGD blow
- down, approx. < 50 kg (100 lbs) per day

Alternative option:

- Manual interval dosing of PAC from bags

Different Injection Points

Utilization of PAC in a Wet FGD

Dosing Systems:

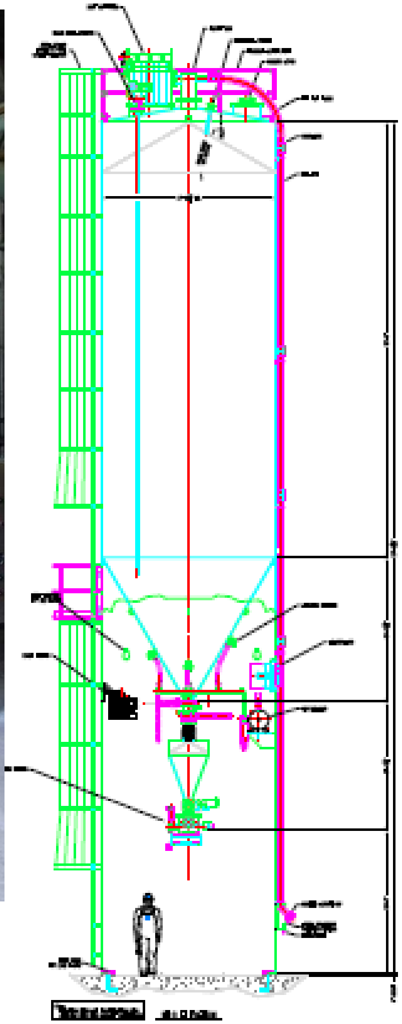
- PAC consumption depends on FGD blow down rate.
- One dosing system can feed multiple units / modules.
- Injection of PAC upstream of FGD recycle pump or directly into the absorber.

Different Injection Points

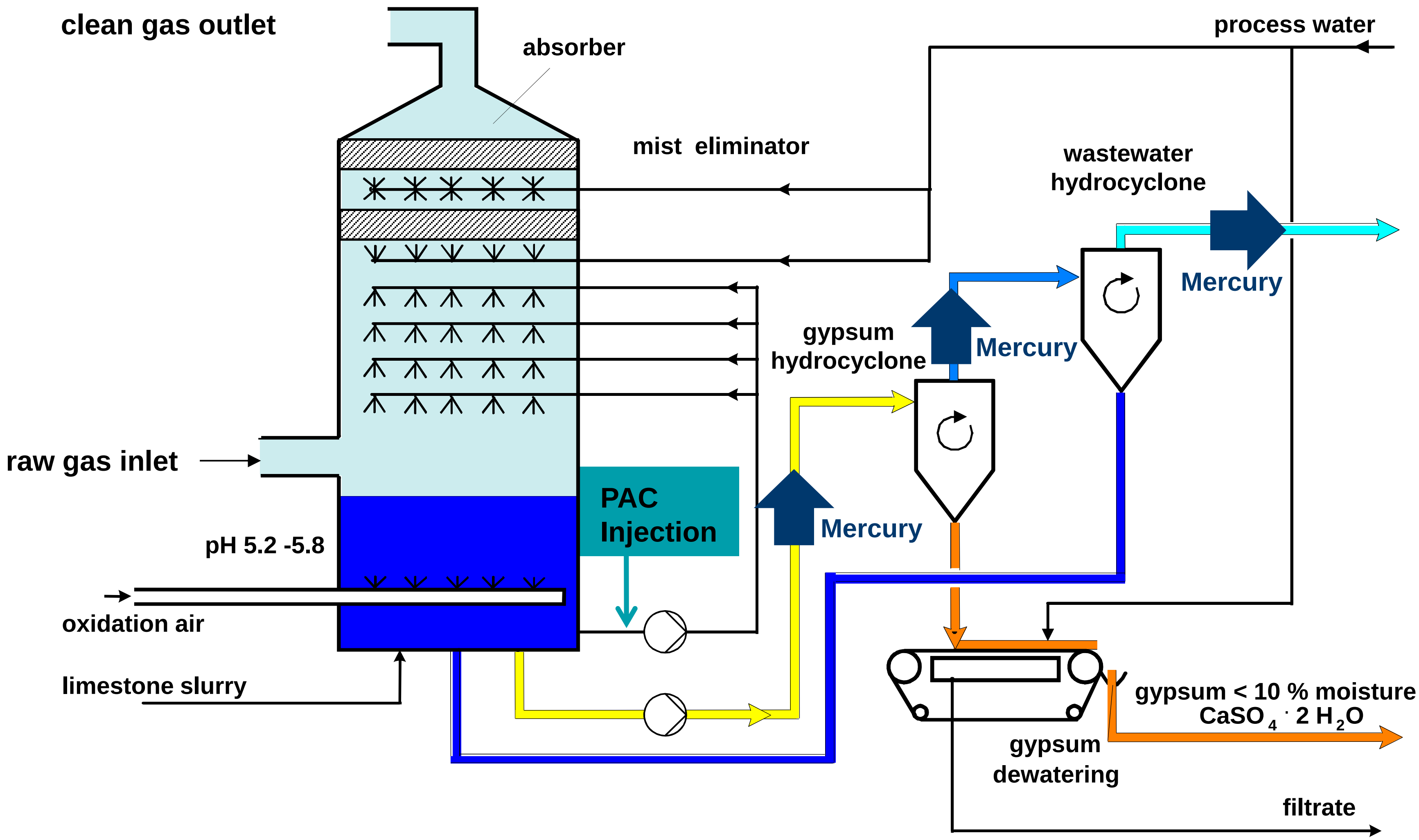
Permanent Installations

- **Installation Possibilities**
  - Either use of supersac or Silo design.
  - Selected unit is dependent upon system / customer requirements.
  - For multiple units, a single pack system into 2 batch tanks for feeding and redundancy.
  - Small foot print for installation.
  - Can be located remotely from modules.

First US Commercial Installation
In final start-up stage



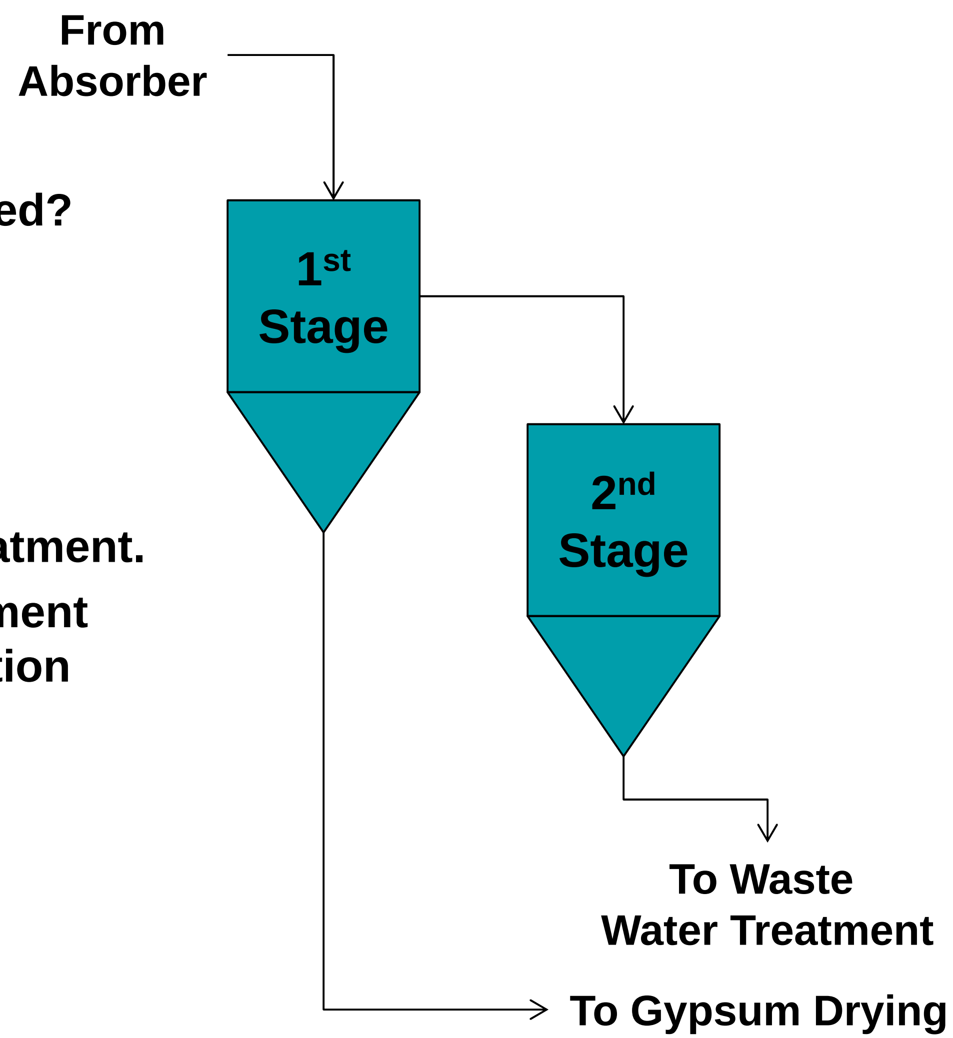
Simplified wFGD Process with Hydroclones



Removal of the Mercury

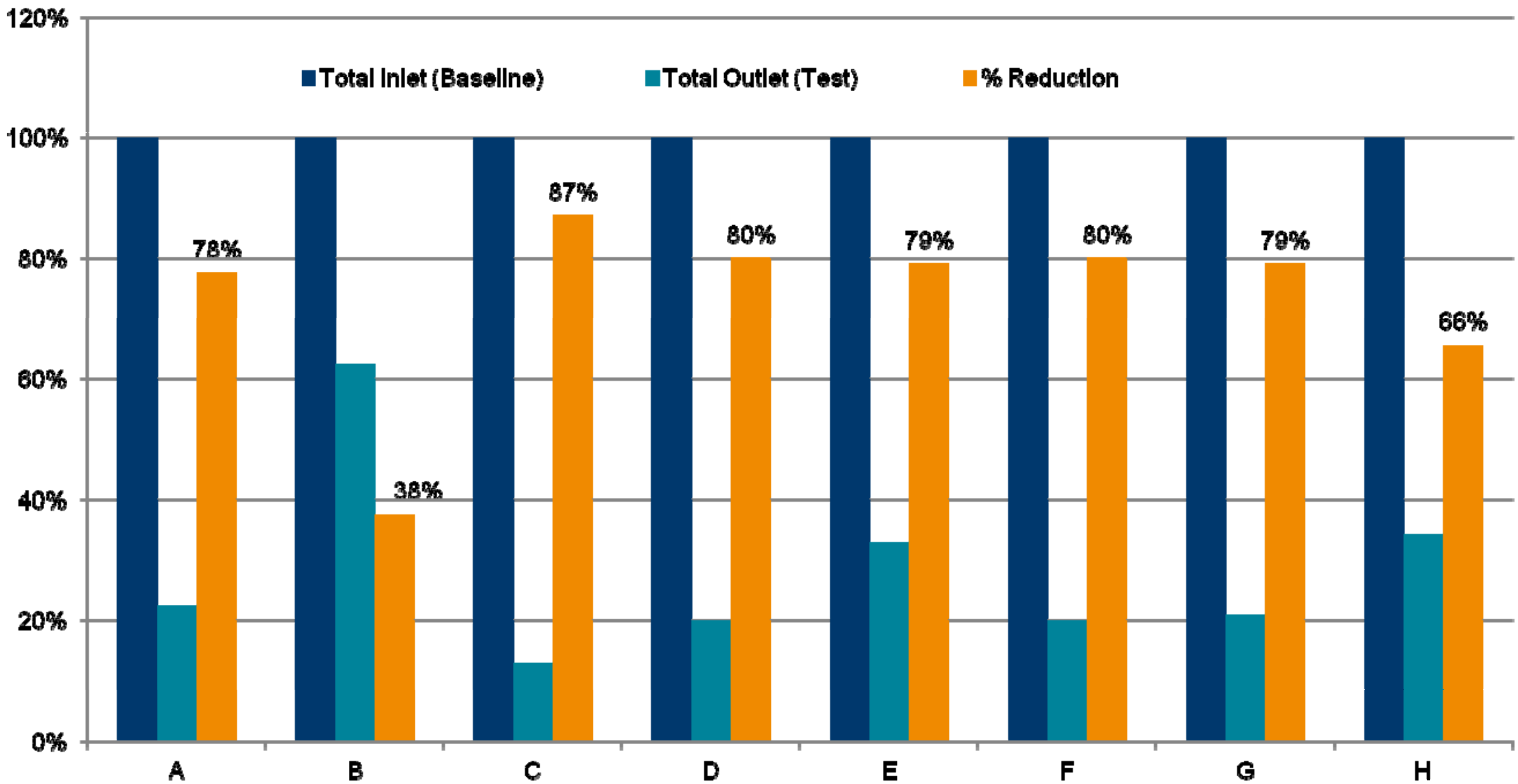
- **Decision Cycle**
  - Is the Gypsum being sold?
  - Does Mercury need to be removed?
  - Landfill / Product Liability.

- **Hydrocyclones is the Mercury Separation System**
  - Mercury to the Waste Water Treatment.
  - Hydrocyclone separation equipment may needs to be 2 stage separation system.
  - Adjustments in the separation equipment may be needed.



Summary Chart

- **Mercury reduction in % at various test sites**



Conclusions

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- Legislation will lead to Mercury capture.
- Oxidation with SCR and/or Halogen can obtain high levels of Mercury oxidation.
- Mercury is readily captured in the wet FGD.
- There are re-emissions technologies that can prevent the re-emission of the Mercury.
- Separation of the Mercury from the Gypsum is critical!
- Tests are not expensive and should be considered to determine the effectiveness.
- Capital cost are low compared to the chemical cost. A life cycle cost should be used for evaluation.

Questions?

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