REINHOLD ENVIRONMENTAL Ltd.

2012 APC Round Table
& Expo Presentation

July 16-17, 2012, in Baltimore, MD / Hosted by Duke Energy, Entergy, FirstEnergy, Southern Company & TVA

Mercury and MATS – Panel Discussion Technologies

2012 Reinhold APC Round Table
July 16, 2012

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Field Demonstration Projects – technology selection Hg, HCl, PM, SO_2, and SO_3 (examples)

Field Demonstration	Examples - Summary Project Descriptions
1	DSI demonstration testing program for Hg, HCl, SO_2, and SO_3 reduction with milled Trona, milled SBC, coal mercury oxidation additives, and powdered activated carbon injection process on a coal-fired power plant to determine capability to meet the proposed MATS emissions limits.
2	DSI field demonstration test program at coal-fired power plants for dry sorbent injection in front of the existing electrostatic precipitators (ESP)s to determine the removal of acid gases (HCl and SO_2) and the impact on the operation of the ESPs and fly ash handling system.
3	DSI Field Testing trials for eight units plus PAC for eight sites – SO_2/HCl/Hg/PM control.
4	DSI Field Testing trials for one unit – HCl control
5	DSI Field Testing for one unit and PAC for one unit – SO_2/PM/Hg control
6	DSI Field Testing for one unit – SO_2/HCl/Hg/PM control
7	PAC Field Testing for three units – Hg control
8	PAC Field Testing for one unit – Hg control
9	PAC Field Testing for one unit – Hg control
10	Field Testing for one unit – Hg control
11	PAC/Trona Field Testing for two units –HCl/SO_3/Hg control
12	DSI Field Testing for one unit – SO_3 control
13	DSI Field Testing for one unit – SO_3 control

Mercury (Hg)
AQCS Technologies Options

- Fuel type **(coal type, oil, biomass fuels, coke, and other fuels)**
- Use existing/upgrade FGD System **(co-benefit Hg rem., Hg re-emission additive)**
- Coal mercury oxidation additives **(e.g. PRB coal)**
- Use existing SCR oxidation **(co-benefit neutral Hg → ionic Hg, e.g. PRB coal)**
- Activated Carbon Injection (ACI) **(brominated, non-brominated PAC, etc.)**
- Flue gas mercury oxidation additives
- Mercury Re-emission additive with FGD System
- Use existing/upgraded Electrostatic Precipitators (ESP)
- Use existing/upgraded Fabric Filter (PJFF)
- Multi-pollutant AQCS **(e.g., ReACT for SO_2/NOx/Hg/PM removal , CCS, co-benefit rem. of Hg)**
- Co-firing Coal with natural gas
- Other

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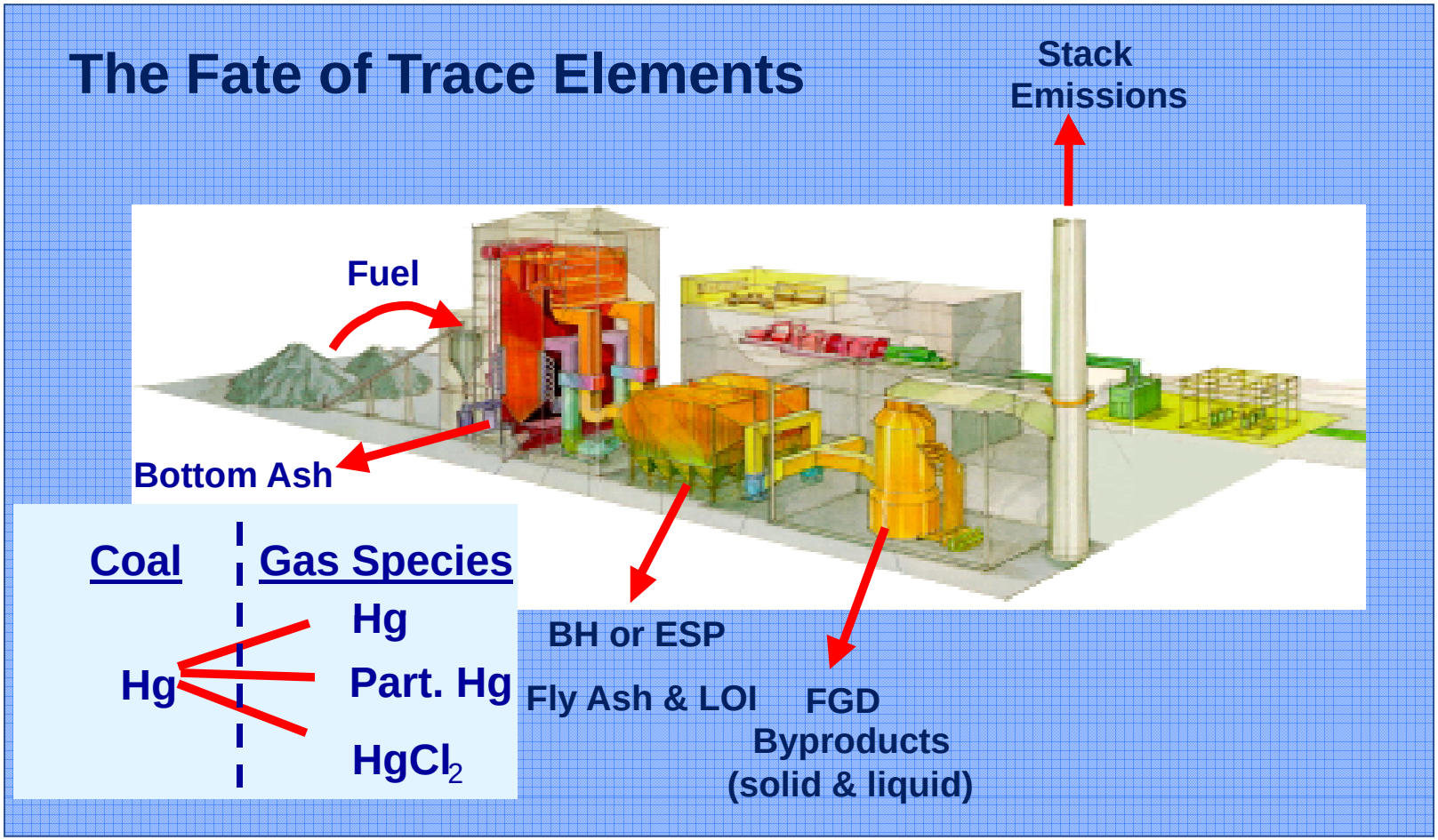
Mercury Control (Hg)

The Fate of Trace Elements – Mercury



Co-benefit Mercury Removal - definition

- The removal of mercury from flue gas in an air quality control device that was primarily designed to control emissions of another specie (SO_2, PM, NOx, SO_3, CO_2, etc).

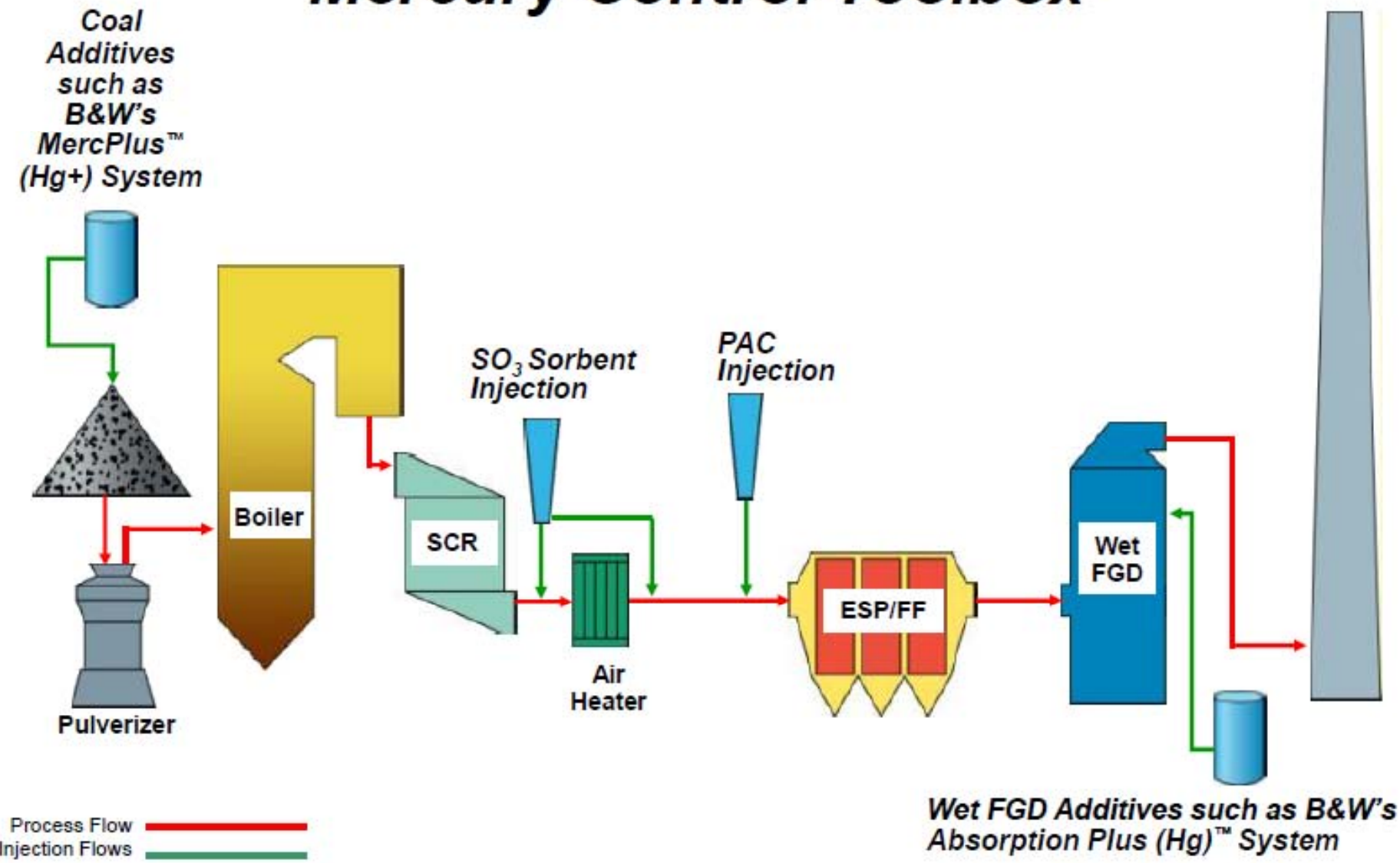
- Although this co-benefit mercury removal may be incidental, there are design and/or operational parameters to enhance Hg removal.

Co-benefit Mercury Removal

(degree of Co-benefit Hg reduction depends on the AQCS device, design, and process parameters)

- SCR Oxidation
  - (neutral Hg → ionic Hg)
- Existing ESP or Baghouse
  - (removes Hg-part, ash LOI for Hg+2 & Hg+0)
- CDS or SDA FGD
  - (Hg removal by lime solids adsorption, cool temp, removal of PM & solids in BH)
- Wet FGD
  - (ionic Hg & PM removal in slurry, cool temp, re-emission inhibitor additives)
- Multi-pollutant Processes
  - (ReACT, ionizer reactors, Hg oxidation, wet absorber with cool temp, WESP)

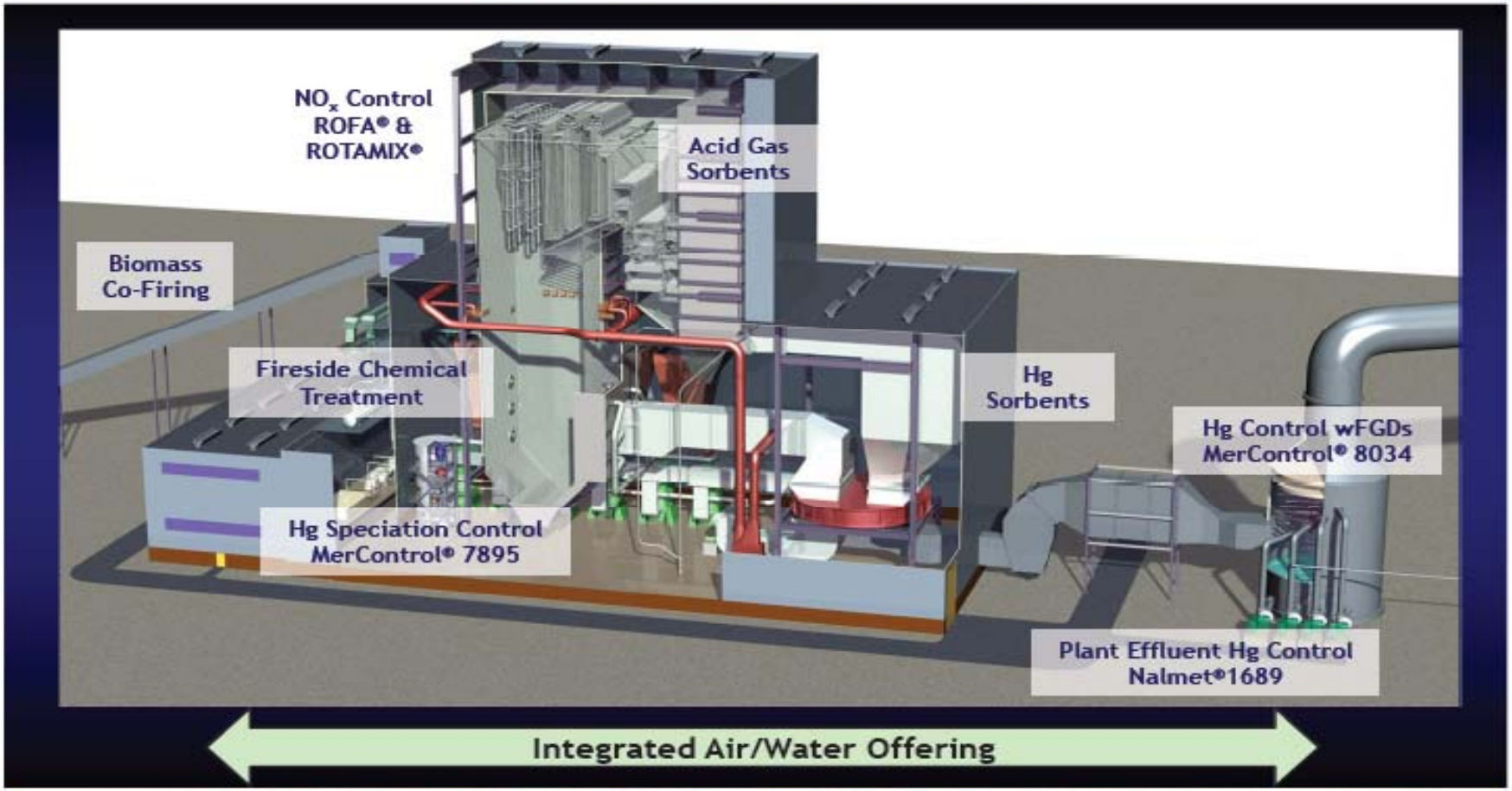
Mercury Control Toolbox



MercPlus™ Fuel Additive from B&W for Low Halogen Coals

- **Increases oxidation of elemental mercury**
- **Reduces PAC consumption**
- **May allow use of standard PAC versus more costly brominated PAC**
- **Injected onto coal prior to coal feeders**
- **Co-benefits Hg removal with FGD**

"Small Environmental Footprint"
Coal-Fired Power Plant



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NALCO
An Ecolab Company

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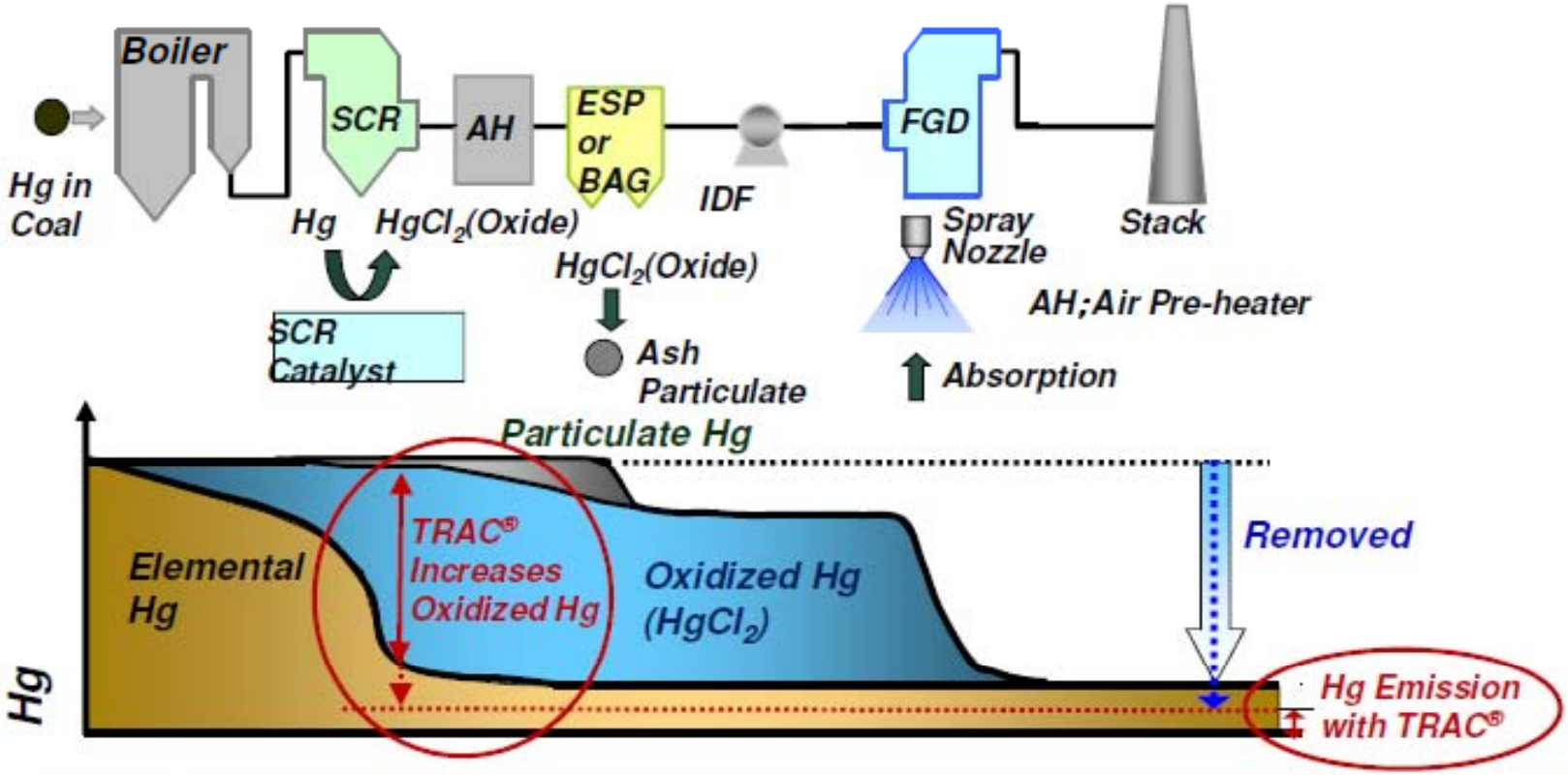
KNX™ for Hg Removal

- KNX™ is a fuel additive that reliably and predictably provides a high degree of Mercury oxidation
- Oxidized Mercury is then more easily controlled by most types of standard air pollution control equipment

Process of Hg Removal by SCR + FGD

HITACHI
Inspire the Next

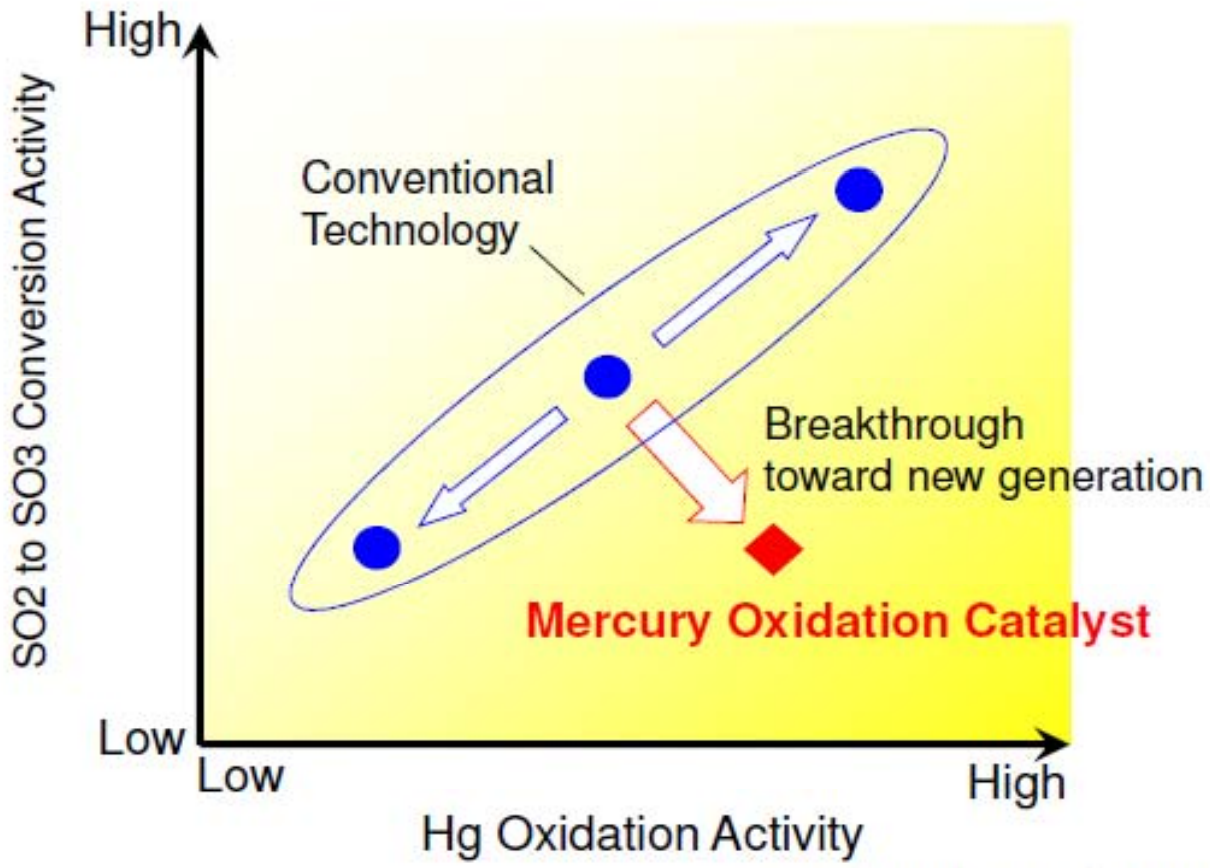


SCR Catalyst is a key component for mercury oxidation

Mercury Oxidation Catalyst

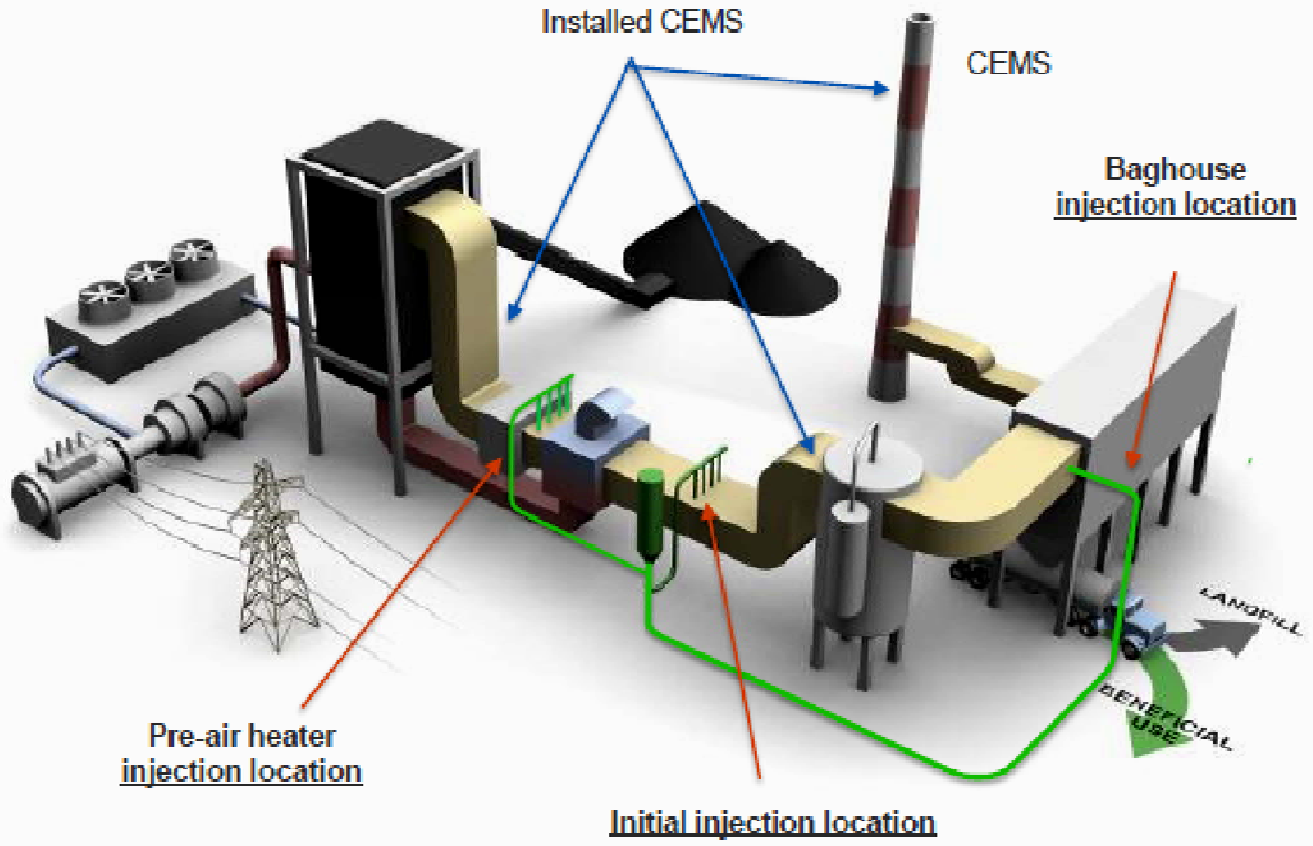
HITACHI
Inspire the Next

Lower SO_2 conversion is required while keeping higher Hg oxidation.



Typical Injection Points (SCR / SDA / BH)

Standard ACI system utilized



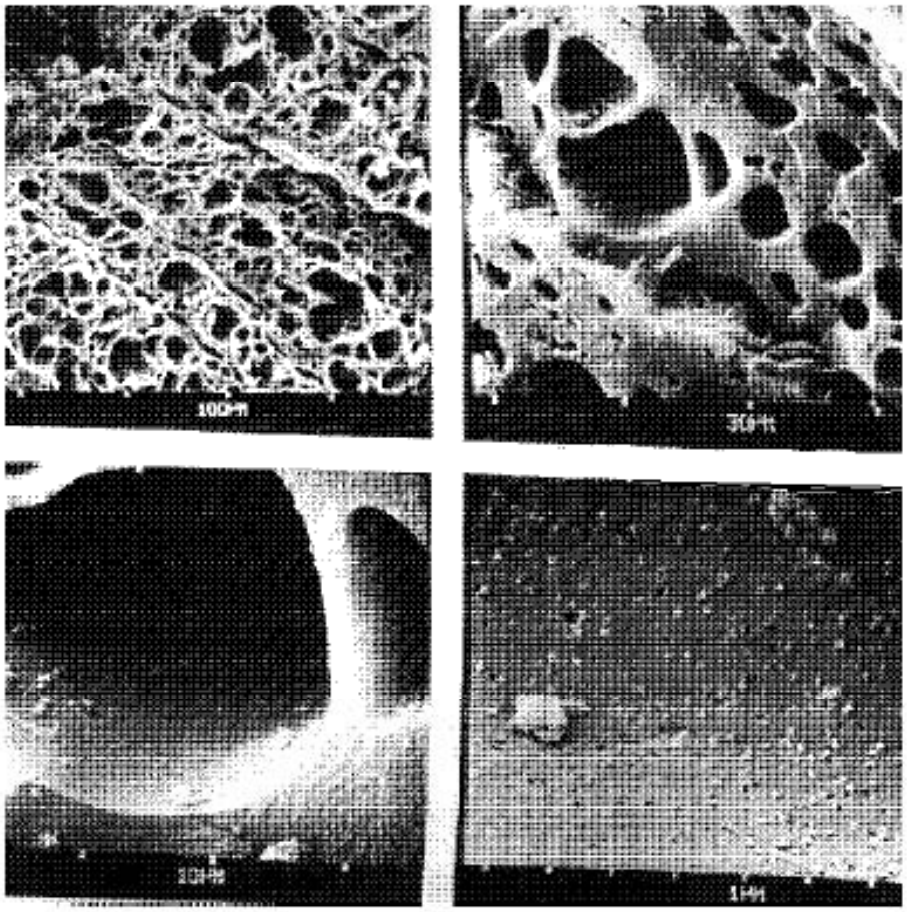
Novinda

Modular Construction
Activated Carbon Silo

Activated Carbon Injection Installation

Overview - DARCO Hg-LH EXTRA

- Created for use in challenging applications in the flue gas market
- Produced using Norit's new patent-pending process.
- Improved oxidative capability resulting in faster adsorption kinetics
- Superior working capacity in bag house applications and higher efficiency in ESPs.



Norit Activated Carbon
leading in purification

Novinda's AS-022 - Hg Removal Product

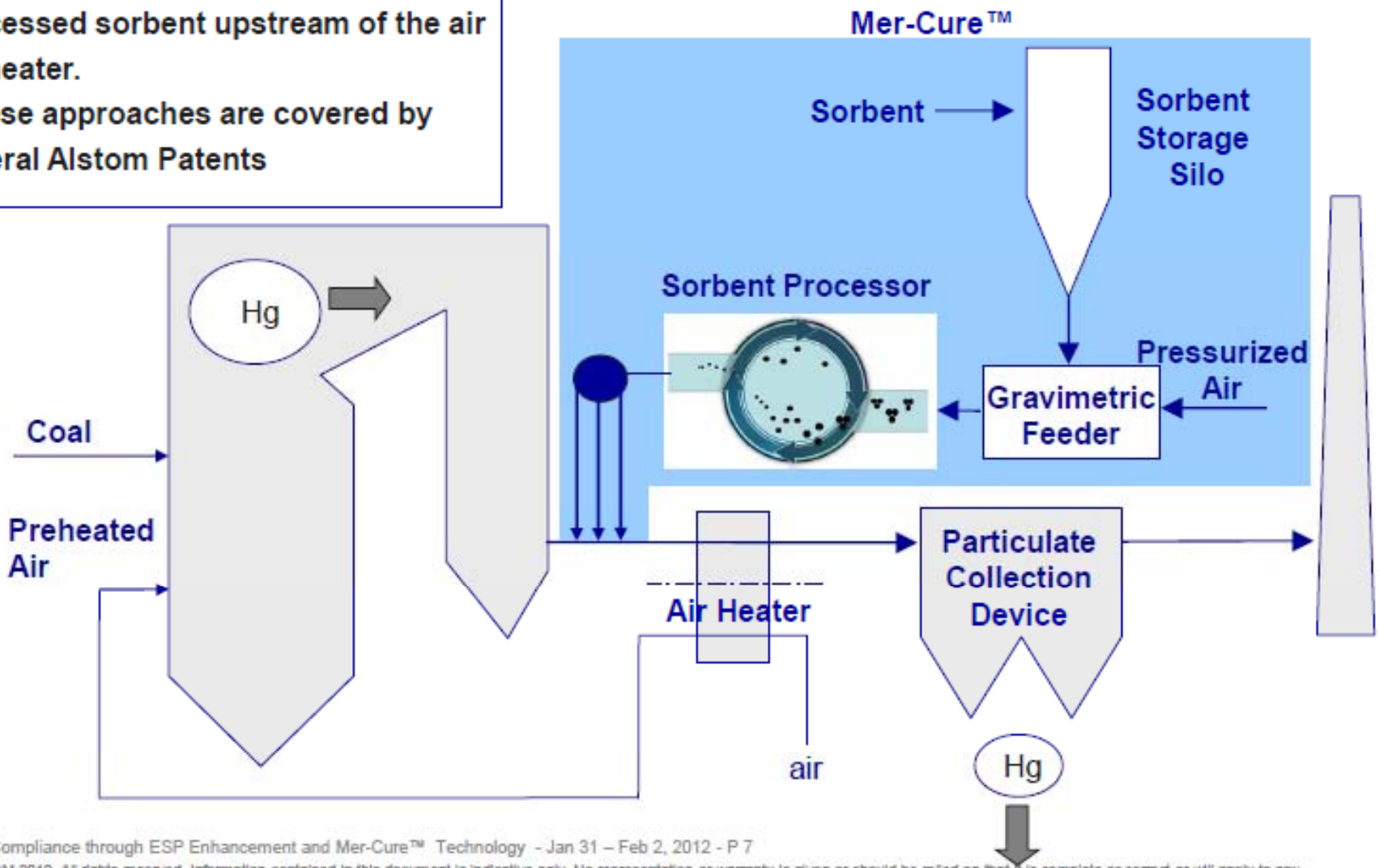
- **Non Carbon** – Mineral Based Product
  - Manufactured using a natural mineral substrate: bentonite.
  - Preserves 'beneficial use' of fly ash as a replacement for Portland cement and maintains gypsum quality.
  - Non-flammable.
  - No degradation on balance of plant.

- **Amended Silicates** - Only Commercially Available Non-Carbon Reagent for Hg control
  - Bentonite is infused with a metal sulfide.
  - Metal sulfide reacts with the mercury to form mercuric sulfide on the surface of the particle.
  - AS-022 creates a chemical reaction vs. adsorption.
  - The product is then removed from the flue gas, along with fly ash, in conventional particulate control equipment, such as a bag-house or electrostatic precipitator.

Mer-Cure™ System Technology

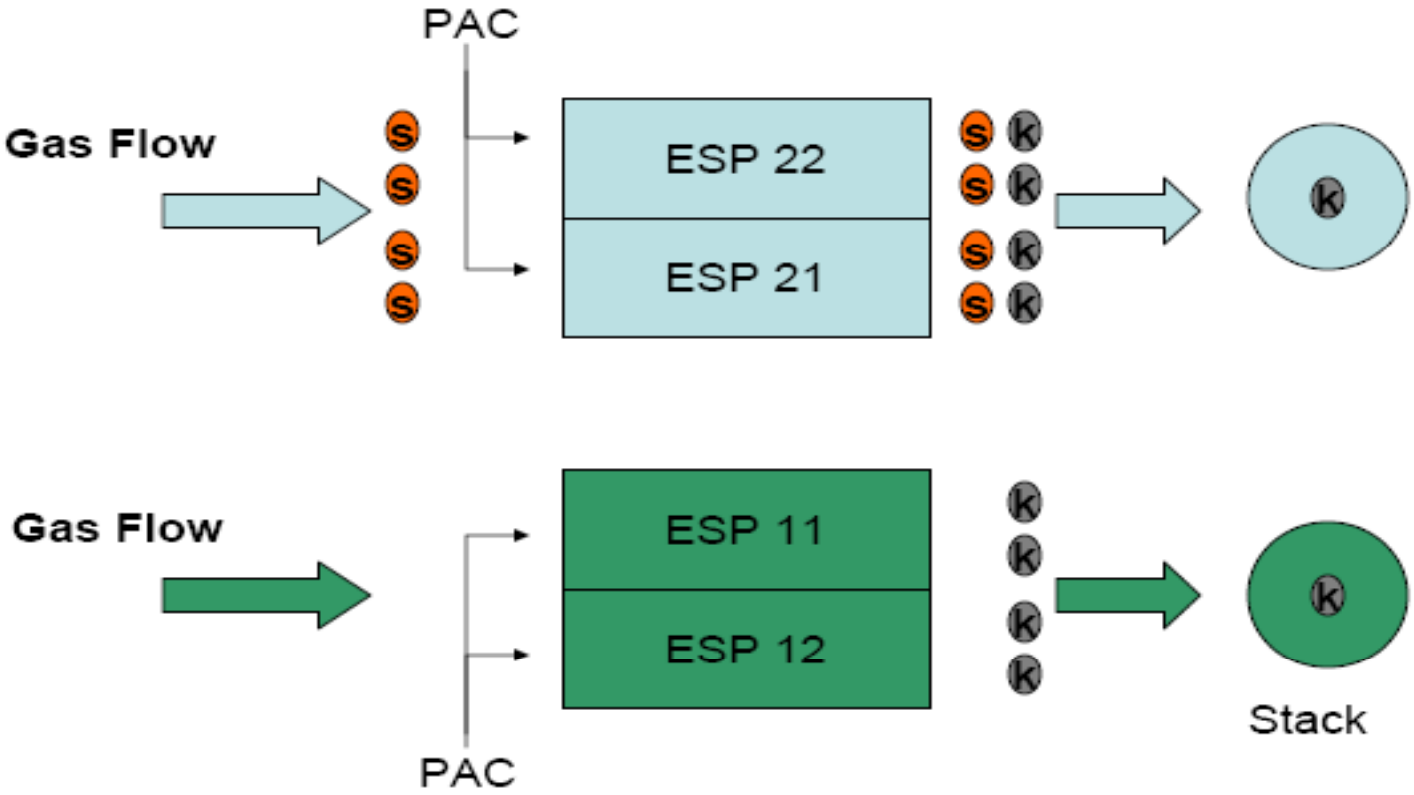
ALSTOM

- Mer-Cure™ uniformly injects on-line processed sorbent upstream of the air preheater.
- These approaches are covered by several Alstom Patents



Sorbent Injection with ESP – Mercury Removal Example

Units 1 and 2 General Arrangement



Sorbent Injection with ESP or SDA/PJFF Mercury Removal Examples

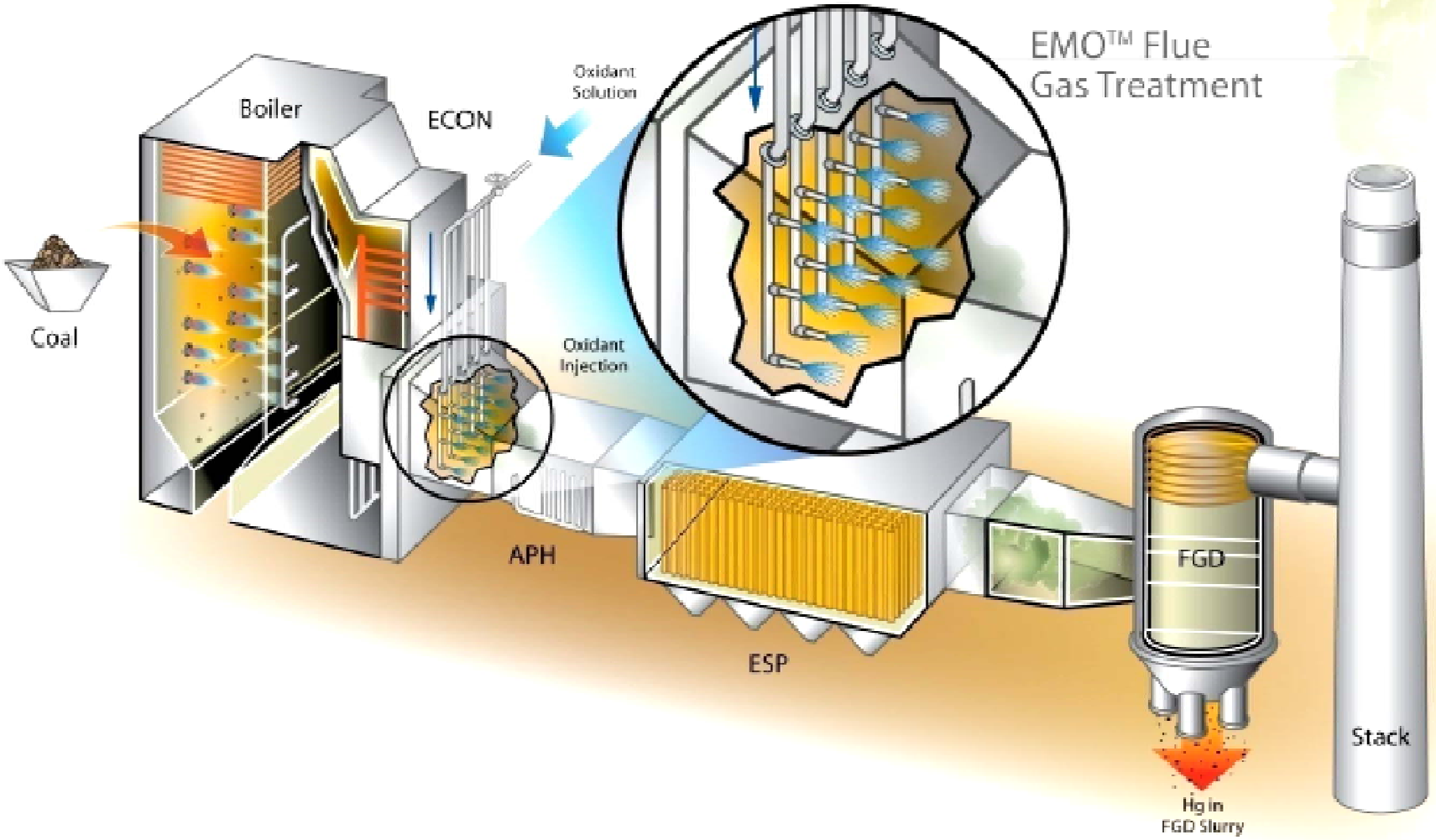
ACI with ESP

ACI with SDA/PJFF

Fabric Filter (PJFF) with Activated Carbon Injection (ACI) Particulate Matter Removal - Example

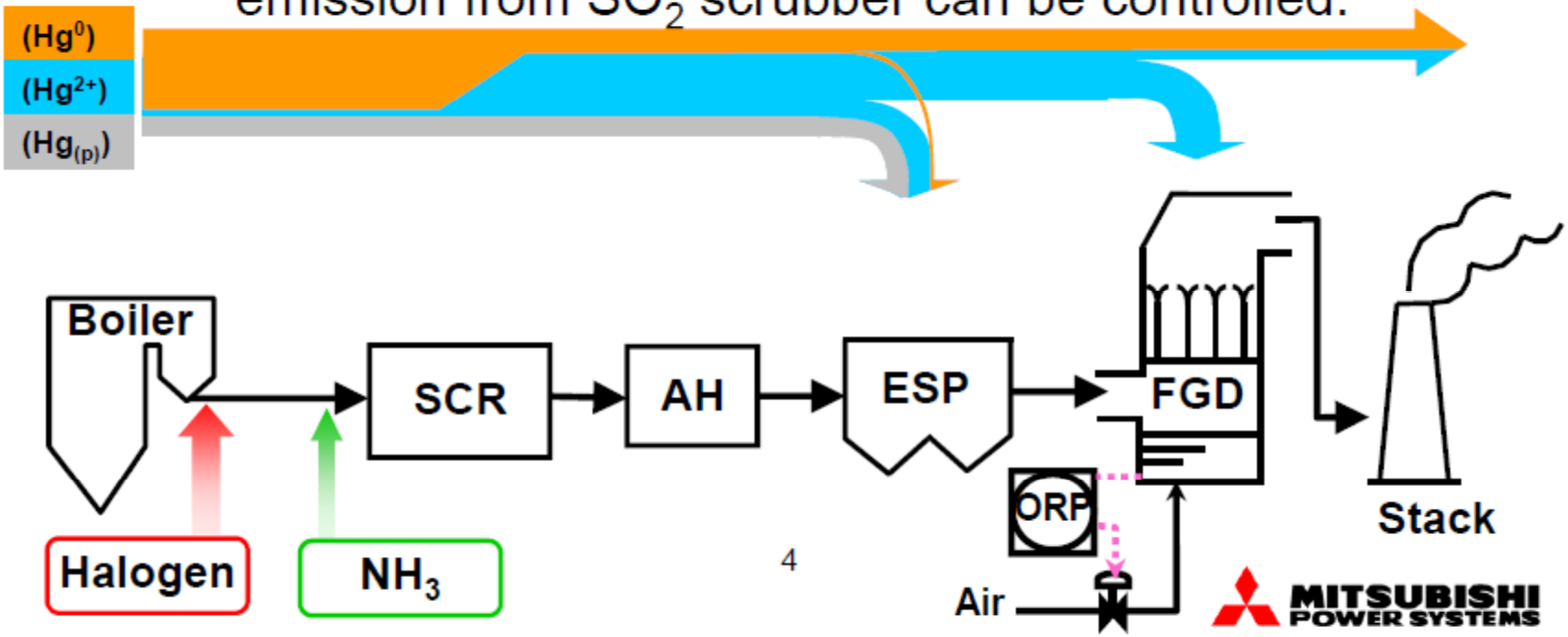
ACI with PJFF

EMO™ Illustration



Mercury treatment system (with SCR/FGD)

- Halogen Injection System
  - ✓ Halogen (NH_4Cl) is injected upstream of SCR to oxidize mercury so that it can be taken out by wet scrubber system.
  - ✓ With proper scrubber chemistry control, Hg re-emission from SO_2 scrubber can be controlled.



MITSUBISHI POWER SYSTEMS

Hg Re-emission across wFGD

- Wet FGDs are capable of 90+% capture of oxidized Hg.
- Then why is the observed range 50-80% capture?
- What limits compliance of EGUs with this configuration?

Hg Speciation **Hg Re-emission**

Definition:

$$[Hg^0]_{stack} > [Hg^0]_{wFGD\ inlet}$$

$$Hg^{2+}_{(aq)} \rightarrow Hg^0_{(g)} \uparrow$$

$$[HgSO_3 + H_2O \rightarrow Hg^0 + H_2SO_4]$$

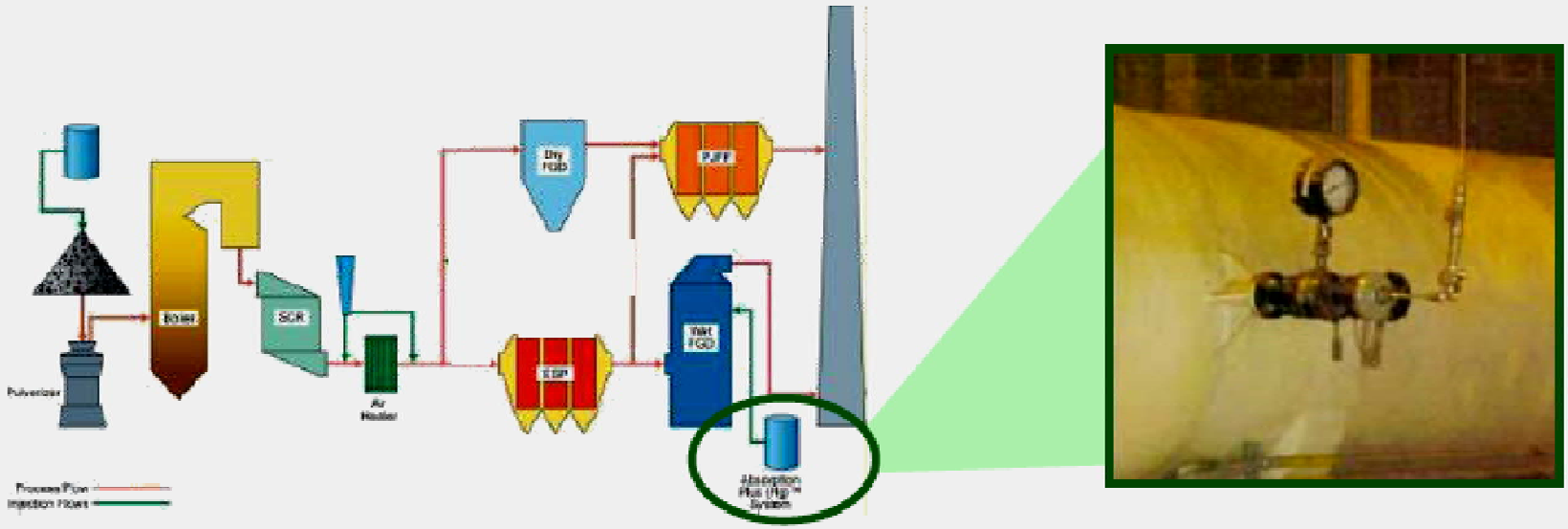
Suggested Reading:

"Bench-scale Kinetics Study of Mercury Reactions in FGD Liquors" Blythe, G. M.; DeBerry, D. W.; April 2007.

"Preventing Mercury Re-emissions in wet Flue Gas Desulfurization Scrubbers at Coal-fired Power Plants using MerControl® 8034 Additive" Stiles, R.L; et al. Preprints of Symposia - American Chemical Society, Division of Fuel Chemistry (2010), 55(1), 164-166..

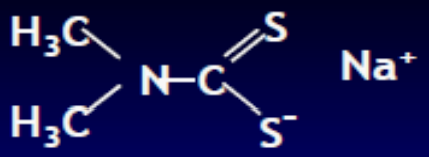
"Demonstrating Mercury Emissions Reduction Cost Management" Meier, J.; Keiser, B.A.; and Higgins, B.; Air Quality VIII, Arlington, VA; 2010.

Absorption Plus (Hg)™ System for Enhanced Mercury Capture

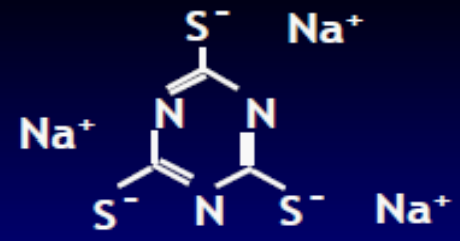


- Proprietary technology from B&W prevents mercury re-emission from Wet FGD
- Removes and retains over 95% of oxidized mercury in FGD

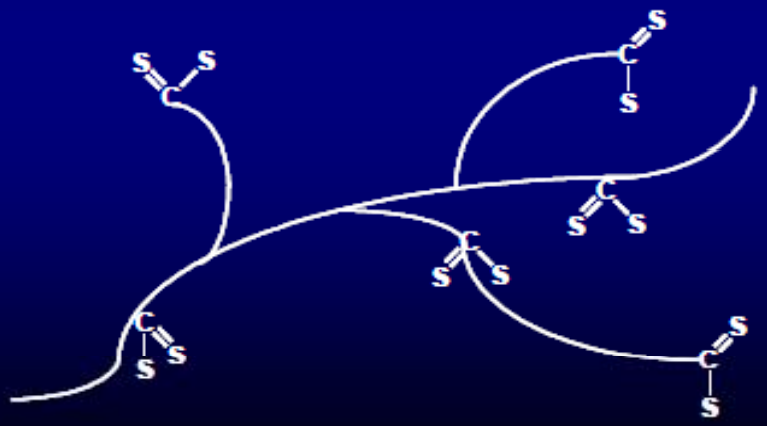
Chemistry of Mercury Chelants



Dimethyl dithiocarbamate
(DTC)



1,3,5-triazine-2,4,6(1H,3H,5H)-trithione
Trimercaptotriazine (TMT)



MerControl 8034 Technology

(poly-dithiocarbamate)

Patented Technology

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FGD CPS WWTS Sludge
(includes mercury removed from waste water)

Sludge may be produced from the clarification of the influent suspended solids to the FGD wastewater treatment system.

Hypothetical composition of generic FGD WWTS sludge:

Calcium sulfate	–	78.0%
Limestone inerts	–	4.7%
Calcium carbonate	–	1.9%
Flyash	–	0.9%
Biosolids	–	1.6%
Metal hydroxides & sulfides, etc	–	12.9%

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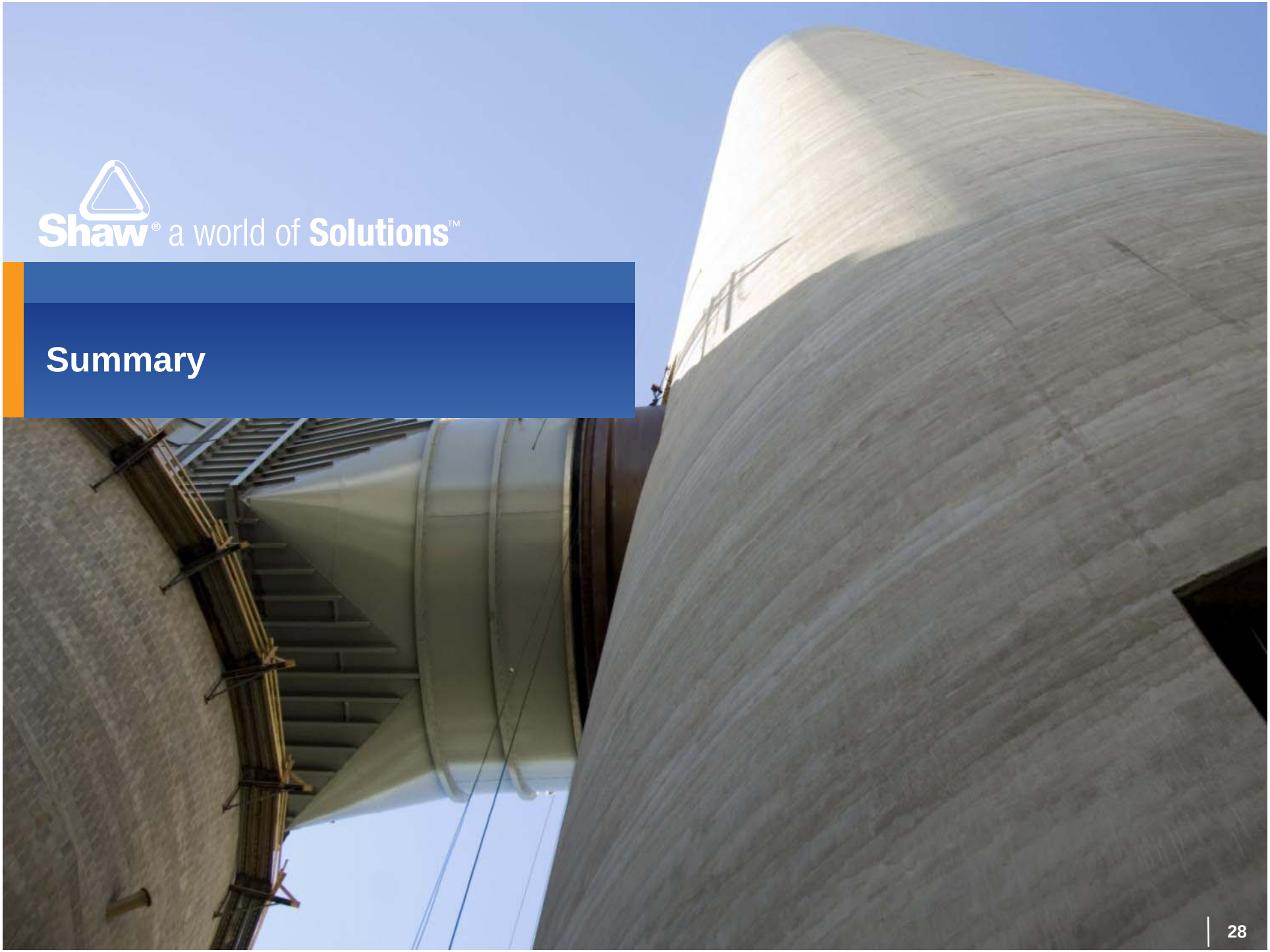
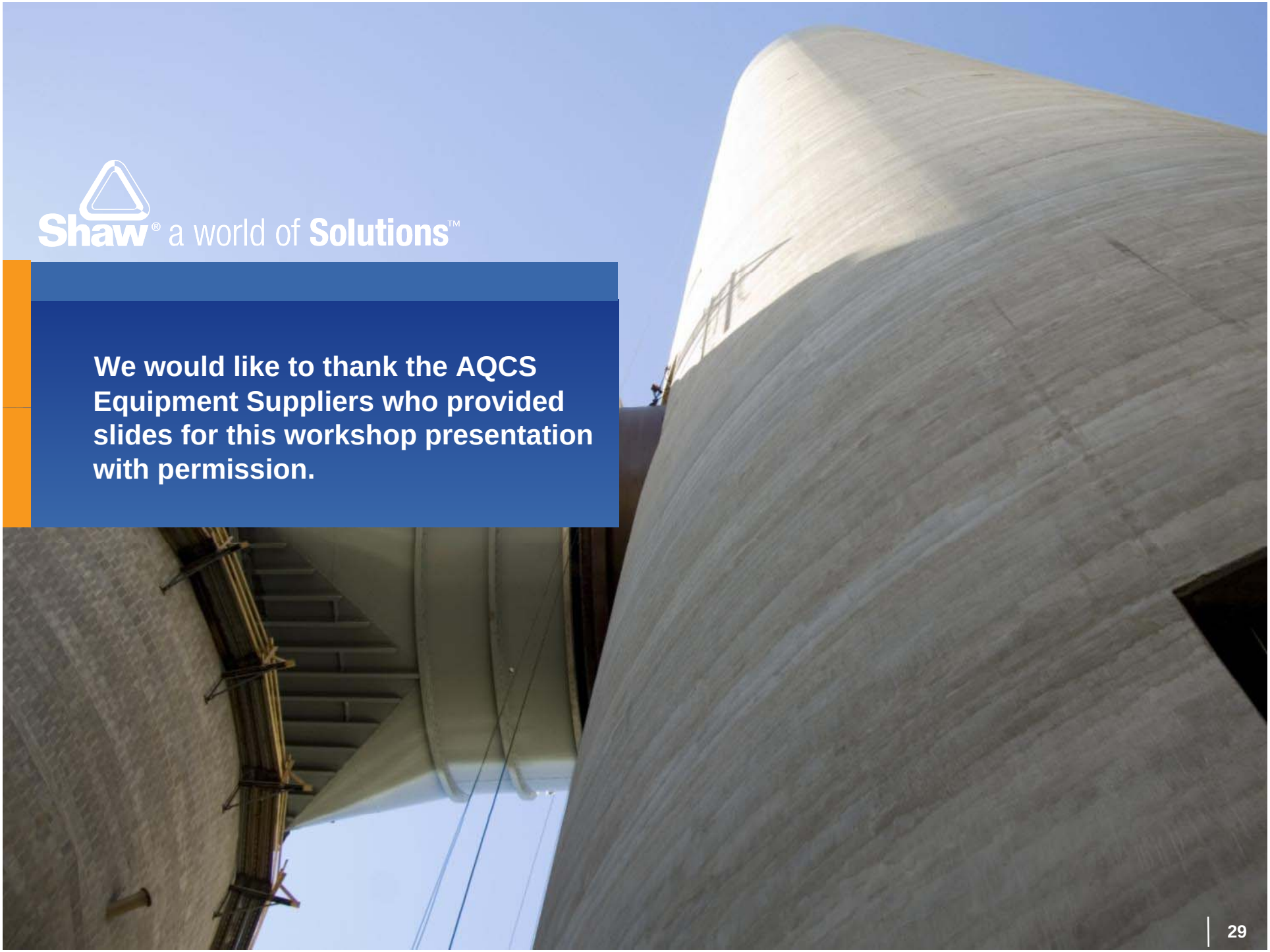
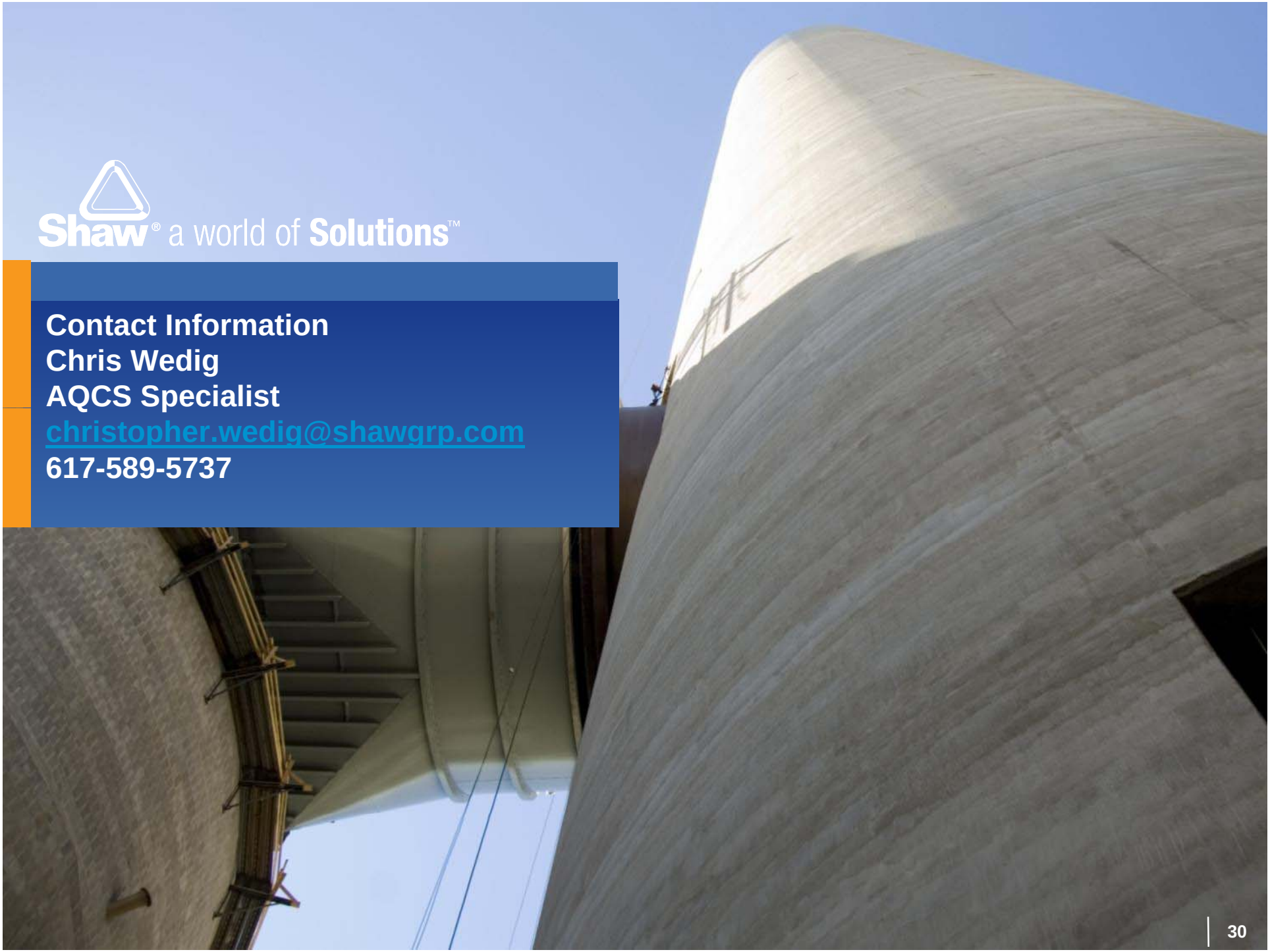
Summary





We would like to thank the AQCS Equipment Suppliers who provided slides for this workshop presentation with permission.



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