REINHOLD ENVIRONMENTAL Ltd.

2012 NOx-Combustion Round Table & Expo Presentation

February 13-14, 2012, in Columbus, OH / Hosted by AEP

3 Top Principles for Mercury Removal

2012 NOx - Combustion Roundtable

Mike Rini

Columbus OH, 13 Feb 2012

POWER | ALSTOM

3 Top Principles for Mercury Removal

1) Oxidize it

- Only oxidized mercury is readily collectable
- Elemental mercury does not collect very well
- Mercury oxidation is facilitated by:
  - Halogens in coal (predominantly Cl, some Br)
  - Additives (e.g., calcium bromide)
  - SCR (oxidation catalyst)

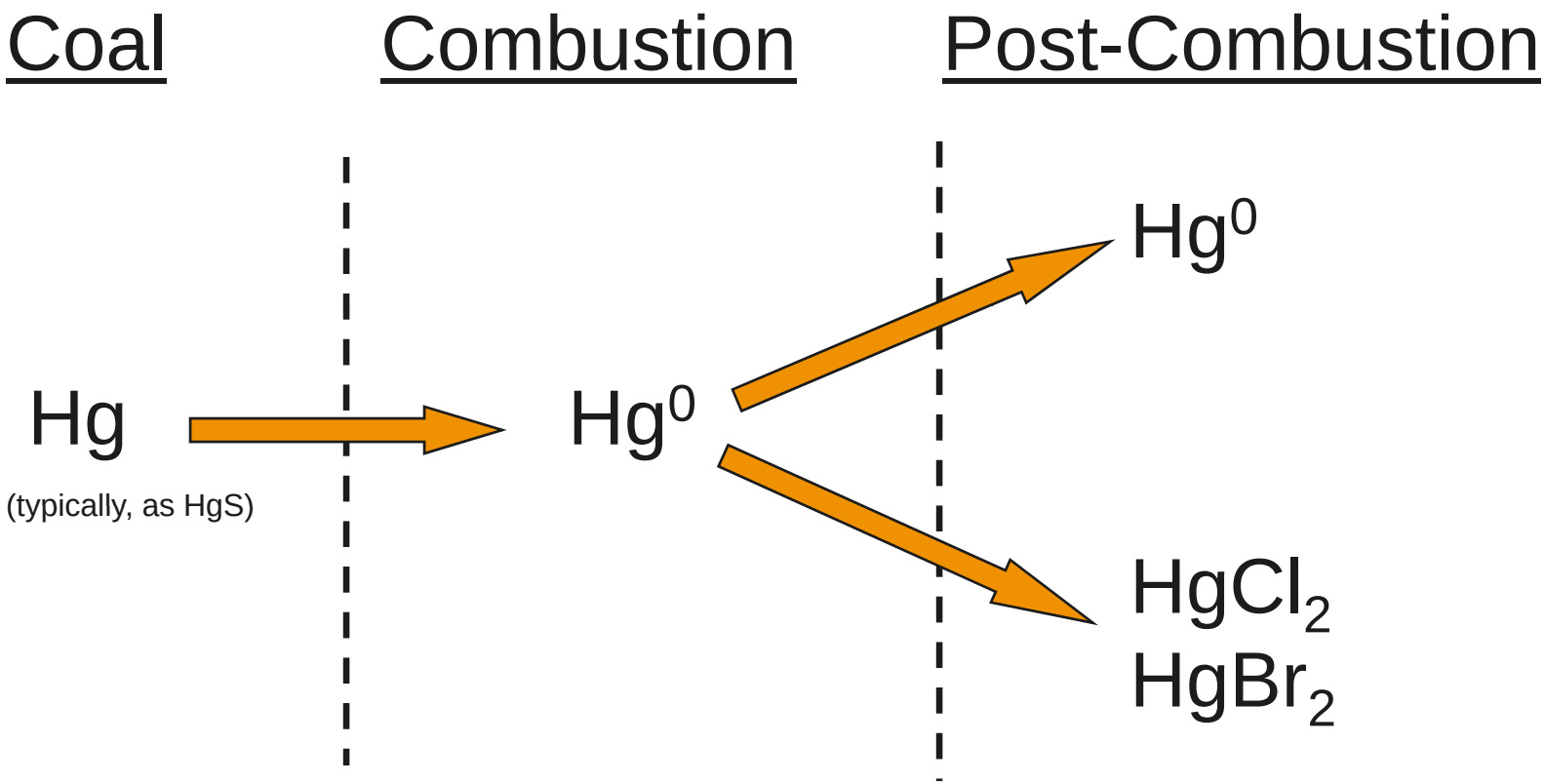
2) Provide capture sites for the oxidized mercury

- UBC/LOI
- PAC
- High surface area dust (ash/DFGD, etc)
- WFGD (oxidized mercury is water soluble)

3) Promptly remove captured mercury from the APCD system

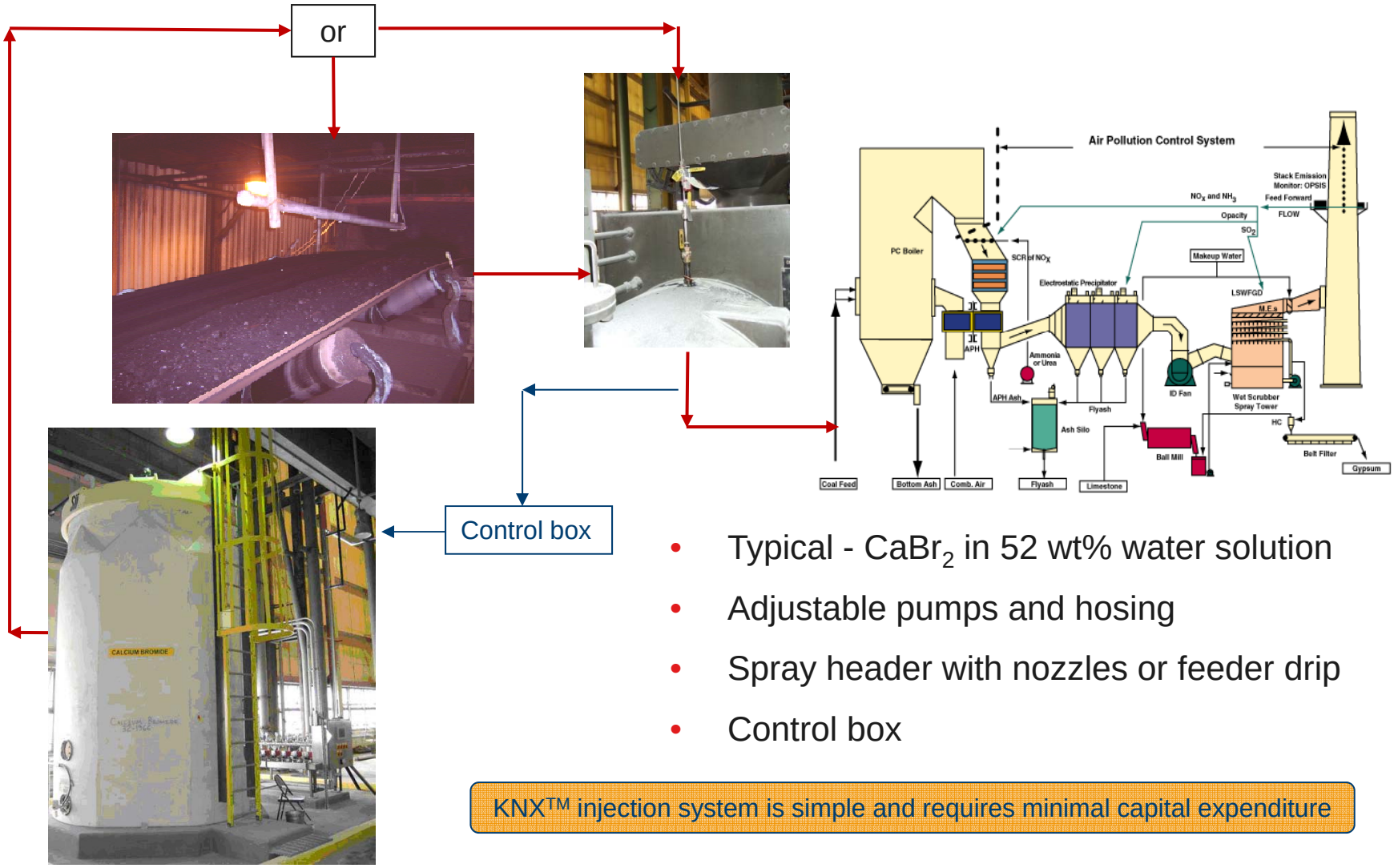
- avoids chemical reduction and re-emission

The Fate of Mercury



Oxidized Mercury is Collectable on Fly Ash and Carbon

Design of the KNX™ Application System

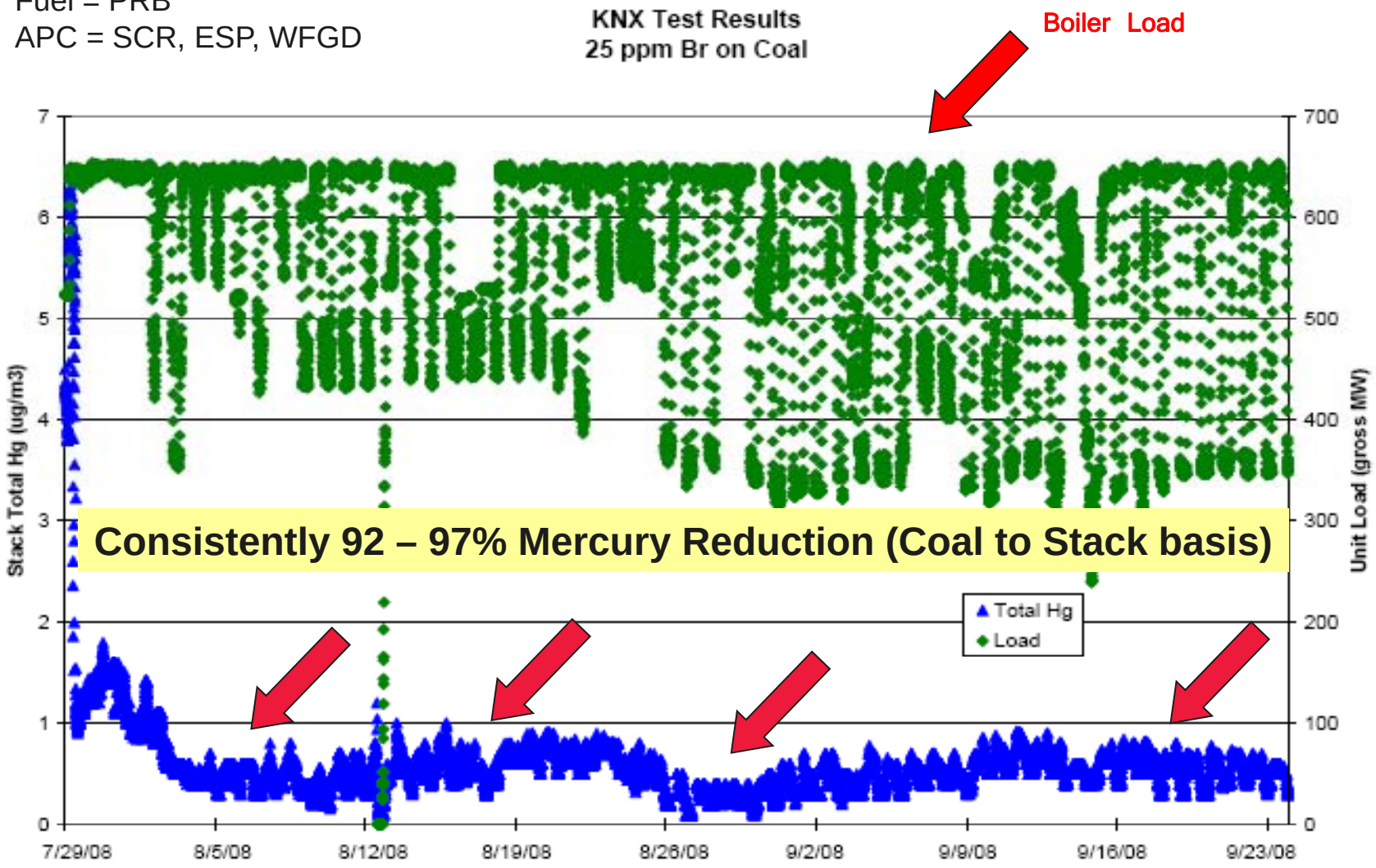


- Typical - $CaBr_2$ in 52 wt% water solution
- Adjustable pumps and hosing
- Spray header with nozzles or feeder drip
- Control box

KNX™ injection system is simple and requires minimal capital expenditure

High Hg Removal at Low Dosage - Pleasant Prairie

Fuel = PRB
APC = SCR, ESP, WFGD



Keys to Mercury Retention in a WFGD

- Limit flyash carry over
  - Flyash supplies metallic ions that reduce oxidized mercury
- Moderate sulfite levels
  - Sulfite promotes stable mercury compounds
  - High sulfite levels promote re-emission
- Moderate Chloride levels
  - Chlorides promote stable mercury compounds
- Significant captured Mercury reports to the gypsum fines. Remove captured mercury from WFGD to avoid reducing reactions

Conclusions

- Several KNX™ systems have been in commercial operation for over 2 years.
- The effectiveness of KNX and its rapid response to fuel Hg and boiler load variations have been demonstrated.
- The combination of pre-combustion bromide addition and non-brominated activated carbon injection (ACI) reliably controls Hg emissions in ESPs.
- KNX™ technology is based on pre-combustion bromide addition which is patent protected and exclusively marketed by ALSTOM in the US and Canada.

www.alstom.com/power

POWER | ALSTOM

Mercury Oxidation Chemistry

- In the flame, all Hg is elemental (Hg^0). Cl and Br from the coal form HCl and HBr.
- On cooling (starting around 1000 °C):

$$4HCl + O_2 \rightarrow 2H_2O + 2Cl_2$$
$$4HBr + O_2 \rightarrow 2H_2O + 2Br_2$$

- Cl_2 (but not Br_2) is consumed by SO_2

$$SO_2 + Cl_2 + H_2O \rightarrow SO_3 + 2HCl$$

- Result is that although total Cl in the coal is far greater than total Br, after combustion, much more Br_2 remains compared to Cl_2
- So that elemental Hg is oxidized by Br_2 to form $HgBr_2$
- In low Chlorine coals (e.g. PRB), addition of Bromine is critical to enhance Hg oxidation
- Bromine is also valuable for bituminous coals to drive additional mercury oxidation