Chicago Bridge and Iron (CB&I) has completed the acquisition of the Shaw Group.

The effective date of the transaction was February 14, 2013.

The combined organization brings the capabilities and experience of over 50,000 employees to the marketplace.

Even though Shaw will undergo many changes under our new company, the people remain and will provide the same level of service and dedication to clients as before.
Mercury and Air Toxics Standard (MATS) published on 2/16/2012, which became effective 60 days later. Compliance needs to be demonstrated by the 1st quarter of 2015.

Final PM limit for Filterable PM only (per EPA Method 5)

Use of the alternate SO\textsubscript{2} limit is not allowed if EGU does not have some form of FGD system and SO\textsubscript{2} CEMS installed.

Where alternate limits are designated with “or” in Table 2 Section 1 of MATS, these pollutants may be used in lieu of pollutants listed in same subsection (e.g. Total non-HAPs may be used in lieu of Filterable PM).

The Hg limit is based on a 30-day boiler operations rolling average.
Injecting chemical: EMO® chemical additives

Mercury Oxidization: \[ \text{Hg}(0) \rightarrow \text{Hg}^{(2+)} \]

Mercury Absorption/Adsorption: in the existing PCD and scrubber

Injection location and temperature: Economizer outlet (> 650°F) or PCD outlet (320°F)
the X ppmv of EMO® injection rate was precisely determined by direct sample titration
Reference Unit 1 Testing Arrangement

- 220 MW, ESP only, 100% PRB

- **EMO™ Injection**
- **PAC/Trona Injection**
- **Coal/Fly Ash**

- **Stack**

- **PC Boiler**

- **Hg Measurement** - Speciated M30B Vapor Halogen Measurement - EPA M26A PMs Measurement - EPA M5

- **Stack EMO™ Injection**
- **330 ± 25°F (180°C)**
- **710 ± 25°F (320°C)**
- **330 ± 25°F (180°C)**
### Reference Unit 1 Hg Data Overview

<table>
<thead>
<tr>
<th>Date</th>
<th>Unit Load From PRB</th>
<th>Max. Hg Injection Rate (lb/MBtu)</th>
<th>EMO™ Injection Rate (ppmvd)</th>
<th>PAC Injection Rate (lb/mmacf)</th>
<th>Trona Injection Rate (lb/Hr)</th>
<th>Stack Hg (lb/TBtu)</th>
<th>Stack Hg (lb/GWh)</th>
<th>Hg Oxidization at Stack (%)</th>
<th>Overall Hg Removal (%)</th>
<th>NOx (lb/MMBtu)</th>
<th>Opacity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/27/12</td>
<td>236 7.8</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>7.50</td>
<td>0.07317</td>
<td>3.8</td>
<td>3.8</td>
<td>0.044</td>
<td>4.5</td>
<td></td>
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<td>0.0</td>
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<td>5.5</td>
<td>0.0</td>
<td>1.200</td>
<td>3.66</td>
<td>0.03570</td>
<td>91.7</td>
<td>53.1</td>
<td>0.045</td>
<td>3.4</td>
<td></td>
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<tr>
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<td>0.0</td>
<td>1.200</td>
<td>0.60</td>
<td>0.00585</td>
<td>99.0</td>
<td>92.3</td>
<td>0.045</td>
<td>3.5</td>
<td></td>
</tr>
</tbody>
</table>

- Baseline Hg emission at the Stack, **7.73 lb/TBtu** on average, with above **95%** Hg (0)
- EMO was observed to produce above **96.5%** Hg oxidation efficiency, improved from **5%**
- EMO was observed to produce above **83.5%** overall Hg removal efficiency
- Combined with Trona, EMO still produced Hg oxidation rate **91.7%** Hg oxidation efficiency, overall Hg removal efficiency decreased down to **53.1%**
- Combined with Trona/PAC, EMO produced Hg oxidation rate **99.0%** Hg oxidation efficiency, overall Hg removal efficiency was determined at **92.3%**
Reference Unit 2 Testing Arrangement

- 440 MW, ESP + FGD, 100% Lignite

![Diagram showing the testing arrangement for Reference Unit 2, including EMO® Injection, APH, ESP, IDF, FGD, Boiler, Stack, and various measurement methods such as Hg, HCl, and PM].

- Coal/Fly Ash/FGD Slurry Sampling/Analysis
- Hg Measurement - Speciated M30B
- HCl Measurement - EPA M26A
- PM Measurement - EPA M5

EMO - MCILVAINE - 2013
EMO® Phase II - 1 Overview (5/22/2012 – 6/12/2012)

- **Hg Oxidization Efficiency:** 91%
- **Overall Hg Removal Efficiency:** 88%
- **Phase II - 1 Optimal EMO® Hg(T):** 3.9 lb/TBtu
- **Optimal EMO® Rate:** 13.5 ppmv
- **Stack Hg (T) (lb/TBtu):**
  - MATS Hg Limit: 4.0 lb/TBtu
  - Hg content in coal varied between 26.6 and 54.1 lb/TBtu, averaged at 33.7 lb/TBtu, Phase 1: 18.0 lb/TBtu

EMO® Injection Concentration (ppmvd)

- Hg Oxidization Efficiency: 80%
- Overall Hg Removal Efficiency: 75%
- MATS Hg Limit: 4.0 lb/TBtu
- Phase I Optimal EMO® Hg(T) Average: 3.7 lb/TBtu
- Optimal EMO® Rate: 6.5 ppmv

Hg content in coal varied between 15.1 and 22.4 lb/TBtu, averaged at 18.0 lb/TBtu
The cost estimates for the first 3 non-EMO™ injection options were based on Hg Content in coal ~20 lb/TBtu. None of them demonstrated MATS compliance!
From various CB&I EMO field trial, SO3 has been observed to inhibit Hg oxidization, Hg2+ adsorption across the ESP, and Hg2+ absorption across the FGD.
~300 MW Gross, SCR + PCD + FGD, AAI was 100’ downstream of the EMO®

Hg in coal: 9.0 lb/TBtu, Sulfur in coal: 3.5%, Stack SO₃ was visible at ~20 ppmv

Baseline Hg stack Hg (T): ~1.7 lb/TBtu

5.0 ppmv of EMO® at PCD outlet, Stack Hg (T): ~1.1 lb/TBtu

2.5 of EMO® at the PCD outlet and AAI at the ID outlet Stack Hg (T): ~0.9 lb/TBtu
Potential SO3 Interferences – Reference Unit 4

MATS Hg Limits: 1.2 lb/TBtu

Test Runs #

EMO® + AAI

EMO® +

Baseline

Baseline

Baseline

EMO® only

EMO

Lb/TBtu

0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8

0 5 10 15 20 25 30 35
Blending 260 ppm of Ca(Br)2 blending in coal requires 57 lb/hr Ca(Br)2 (110 lb/hr of 52% Ca(Br)2 solution). This equates to 0.28 lb-mol of Ca(Br)2, which generates 0.56 lb-mol available Br material in flue gas in the form of Br2 or HBr.

For 3.3 ppmv EMO™ injection at 195 MW gross generation, it would require 23.1 lb/hr of HBr injection (48 lb/hr of 48% HBr solution). This equates to 0.29 lb-mol of HBr, which generates 0.29 lb-mol available Br in flue gas.

Hence applying Ca(Br)2 could put approximately 50% of the Br material to waste (0.29 lb-mol vs. 0.56 lb-mol), *Excessive Stack Br2 Emission – Title 3 HAPS*

the difference in annual cost is approximately $120K for a 200 MW unit

**HBr is a more effective material promoting Hg oxidization**
Observations & Recommendations

► EMO® Injection successfully demonstrated Hg compliance to MATS >90% plus stack Hg oxidization efficiency), for Lignite, Bituminous, & Sub-Bituminous

► EMO® has been repeatedly observed to Improve Hg re-emission across the scrubber with a means of precise control

► The flue gas SO₃ emission was observed to inhibit Hg oxidization and oxidized Hg capture across the scrubber - Hydrated lime injection mitigated SO₃ interference improving Hg oxidation and removal

► EMO® injection does not create impact for the fly ash beneficial use/disposal (No metal leaching issues observed)

► EMO® was proven to be ~70% more cost-effective than PAC injection and ~50% more cost-effective than other fuel halogen additives, such as Ca(Br2)
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