EMO®

March 28, 2013

Bobby I.T. Chen
Client Program Manager

Shaw Group is now Chicago Bridge & Iron

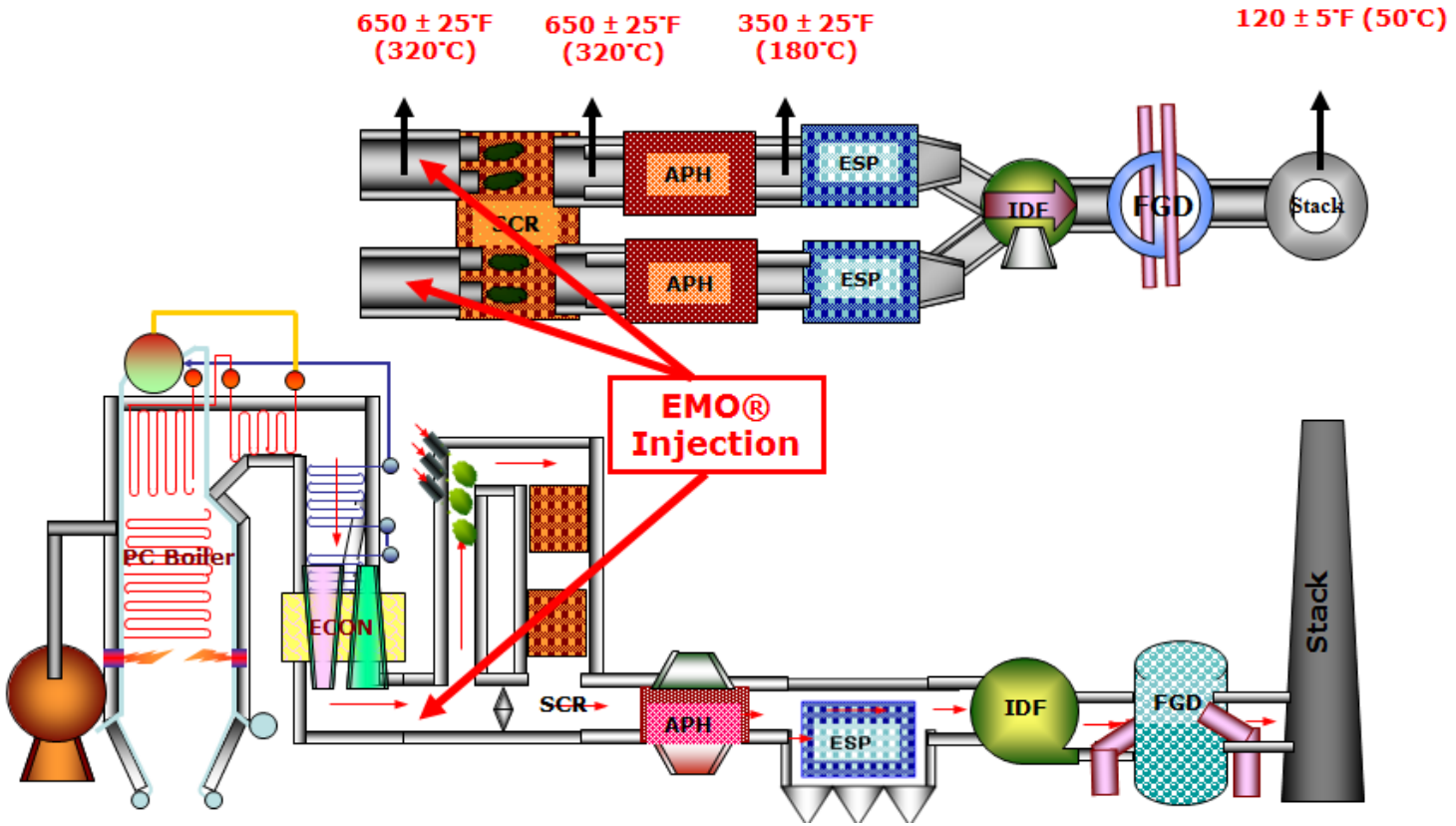
- Chicago Bridge and Iron (CB&I) has completed the acquisition of the Shaw Group.
- The effective date of the transaction was February 14, 2013.
- The combined organization brings the capabilities and experience of over 50,000 employees to the marketplace.
- Even though Shaw will undergo many changes under our new company, the people remain and will provide the same level of service and dedication to clients as before.

MATS Overview

Subcategory	Total Filterable Particulate Matter **(PM)**	Hydrogen Chloride **(HCl)**	Mercury **(Hg)**
Existing coal-fired unit designed for coal **> 8,300** Btu/lb	**0.030** lb/MMBtu (**0.30** lb/MWh)	**0.0020** lb/MMBtu (**0.020** lb/MWh)	**1.2** lb/TBtu (**0.010** lb/GWh)
Existing coal-fired unit designed for coal **< 8,300** Btu/lb	**0.030** lb/MMBtu (**0.30** lb/MWh)	**0.0020** lb/MMBtu (**0.020** lb/MWh)	**4.0** lb/TBtu (**0.040** lb/GWh)

- 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_2 limit is not allowed if EGU does not have some form of FGD system and SO_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**

EMO® Injection General Arrangements



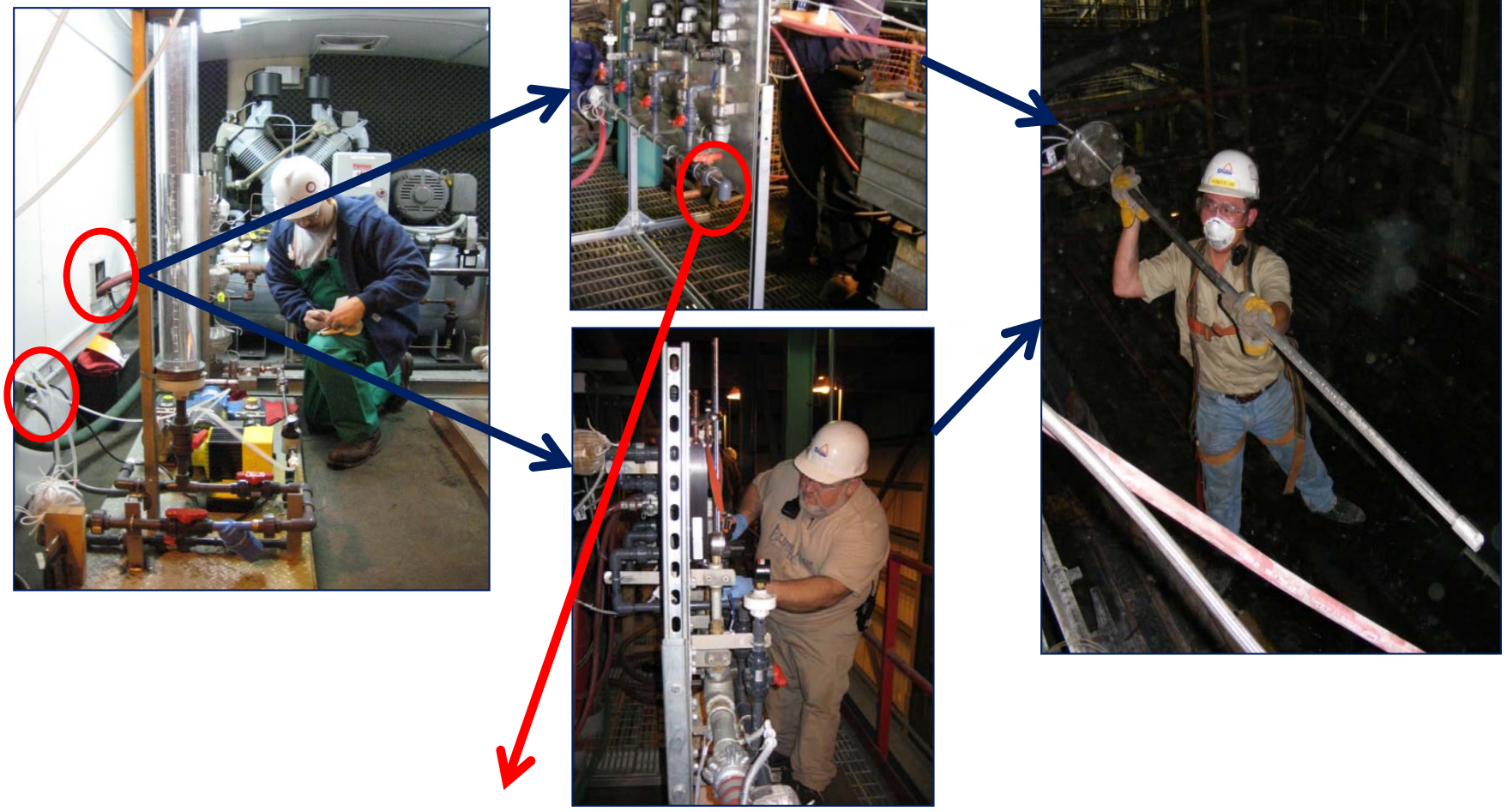
- Injecting chemical: EMO® chemical additives

  Mercury Oxidization: **Hg(0)** → **$Hg^{(2+)}$**

  Mercury Absorption/Adsorption: in the existing PCD and scrubber

- Injection location and temperature: Economizer outlet (**> 650**°F) or PCD outlet (**320**°F)

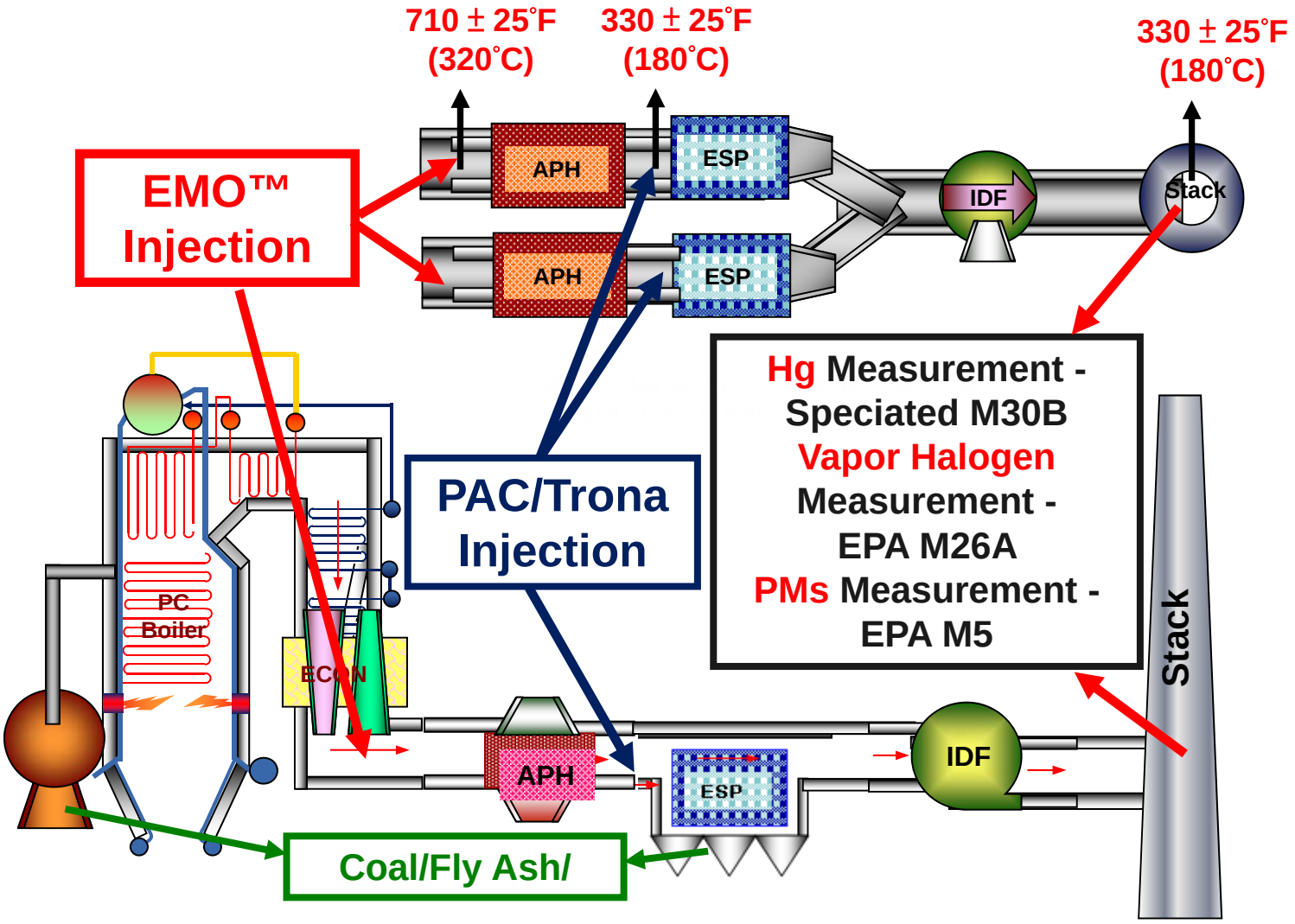
EMO® Injection General Arrangements



- 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



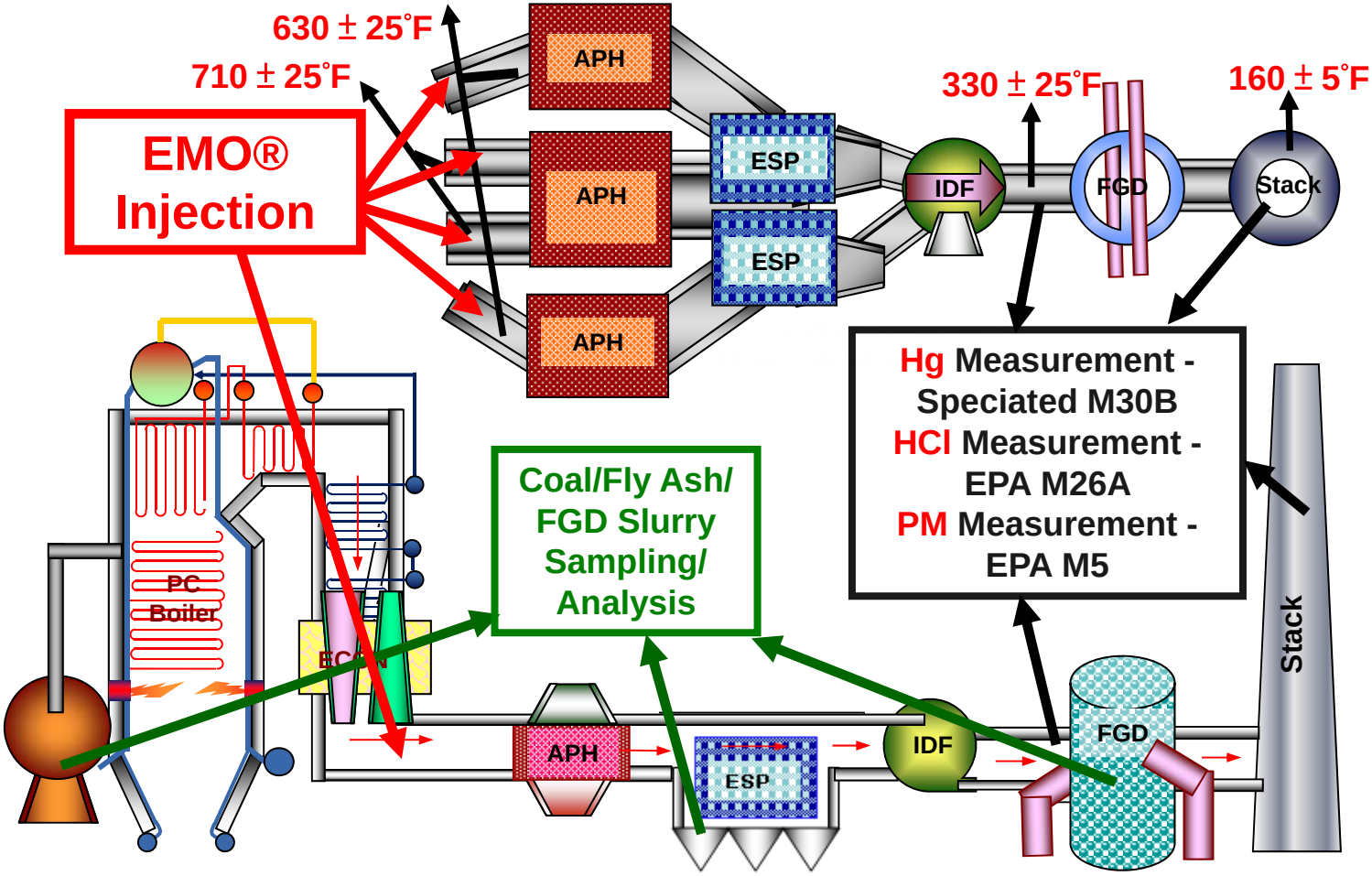
Reference Unit 1 Hg Data Overview

Date	Unit Load	Max. Hg From PRB	EMO™ Injection Rate	PAC Injection Rate	Trona Injection Rate	Stack Hg	Stack Hg	Hg Oxidization at Stack	Overall Hg Removal	NOx	Opacity
mm/dd/yy	(MW)	(lb/TBtu)	(ppmvd)	lb/mmacf	(lb/Hr)	(lb/TBtu)	(lb/GWh)	(%)	(%)	(lb/MMBtu)	(%)
5/27/12	236	7.8	0.0	0	0	7.50	0.07317	3.8%	3.8%	0.044	4.5
	235	7.8	0.0	0	0	7.90	0.07707	6.4%	-1.3%	0.042	4.5
6/7/12	234	7.8	4.4	0	0	1.49	0.01457	97.4%	80.9%	0.043	4.2
	237	7.8	6.5	0	0	1.16	0.01136	97.7%	85.1%	0.045	3.4
6/8/12	235	7.8	5.5	0	1200	3.66	0.03570	91.7%	53.1%	0.045	3.6
6/8/12	235	7.8	10.0	2	1200	0.60	0.00585	99.0%	92.3%	0.045	3.5

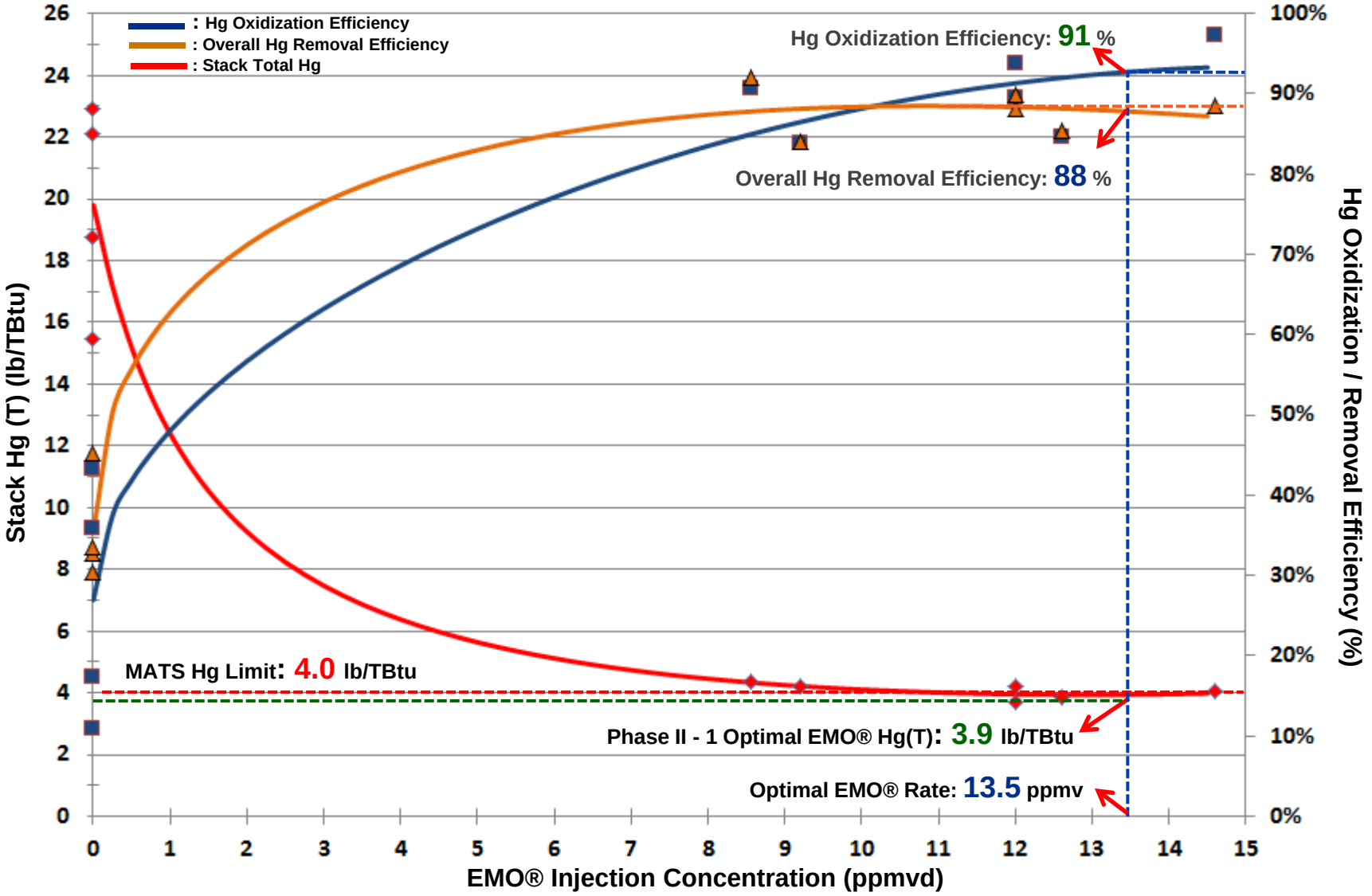
- Baseline Hg emission at the Stack, **7.73** lb/TBtu on average, with above **95%** Hg (0)
- EMO was observed to produce above **96.5%** Hg oxidization efficiency, improved from **5%**
- EMO was observed to produce above **83.5%** overall Hg removal efficiency
- Combined with Trona, EMO still produced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

Reference Unit 2 Testing Arrangement

- 440 MW, ESP +FGD, 100% Lignite

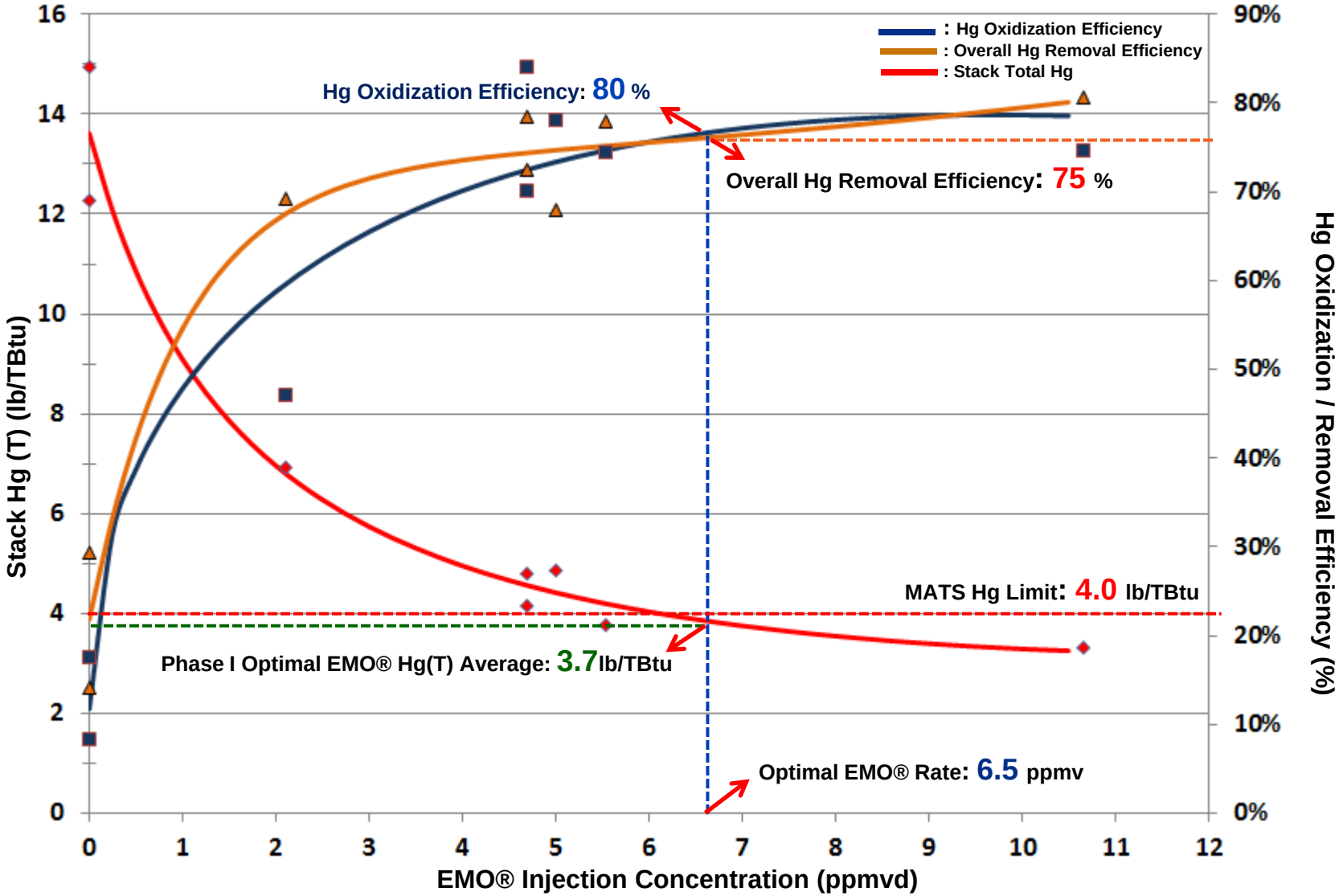


EMO® Phase II - 1 Overview (5/22/2012 – 6/12/2012)



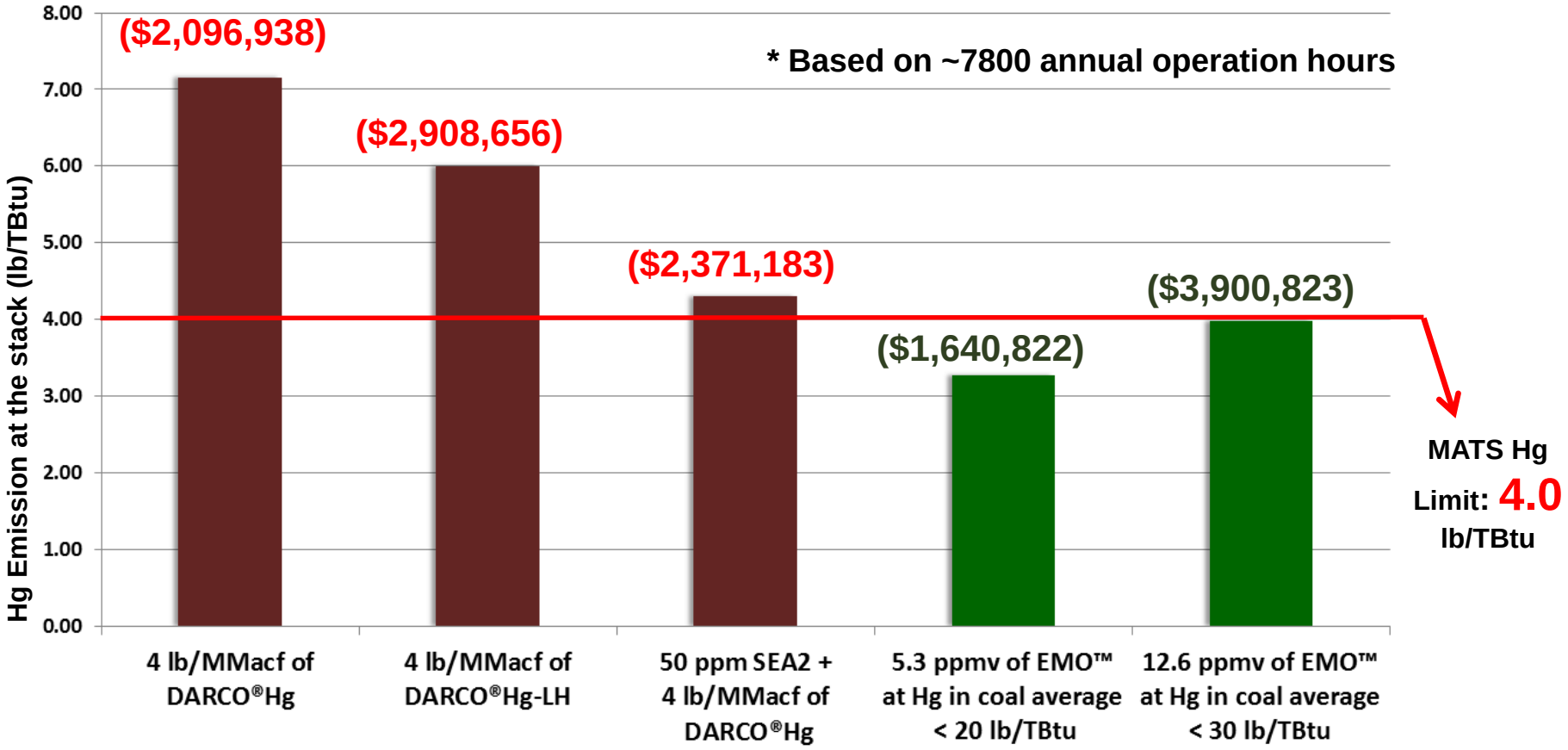
- Hg content in coal varied between **26.6** and **54.1** lb/TBtu, averaged at **33.7** lb/TBtu, Phase 1: **18.0** lb/TBtu

EMO® Phase I Overview (11/14/2011-11/17/2011)



- Hg content in coal varied between **15.1** and **22.4** lb/TBtu, averaged at **18.0** lb/TBtu

Reference Unit 3 Economics Analysis

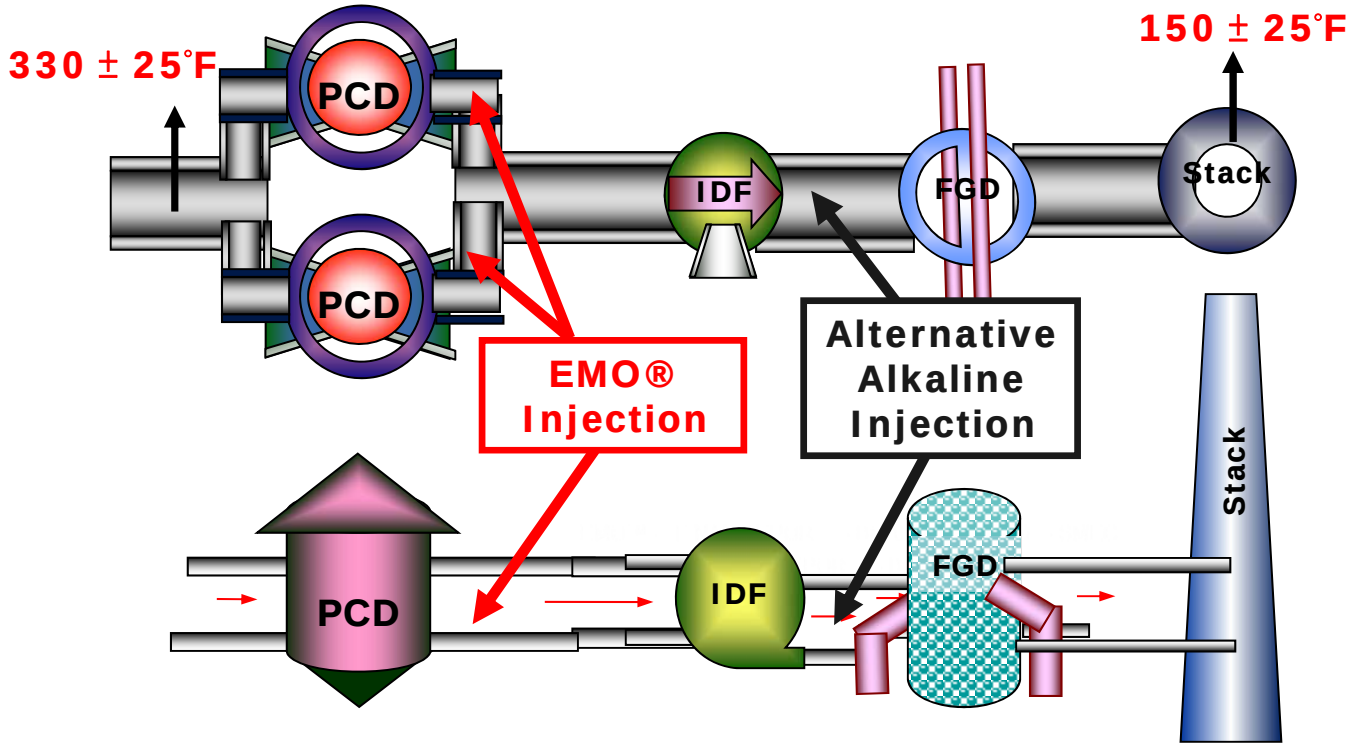


- The cost estimates for **the first 3 non-EMO™ injection options** were based on Hg Content in coal **~20** lb/TBtu. **None of them demonstrated MATS compliance!**

Stack Visible Blue Plum – SO_3 Interferences

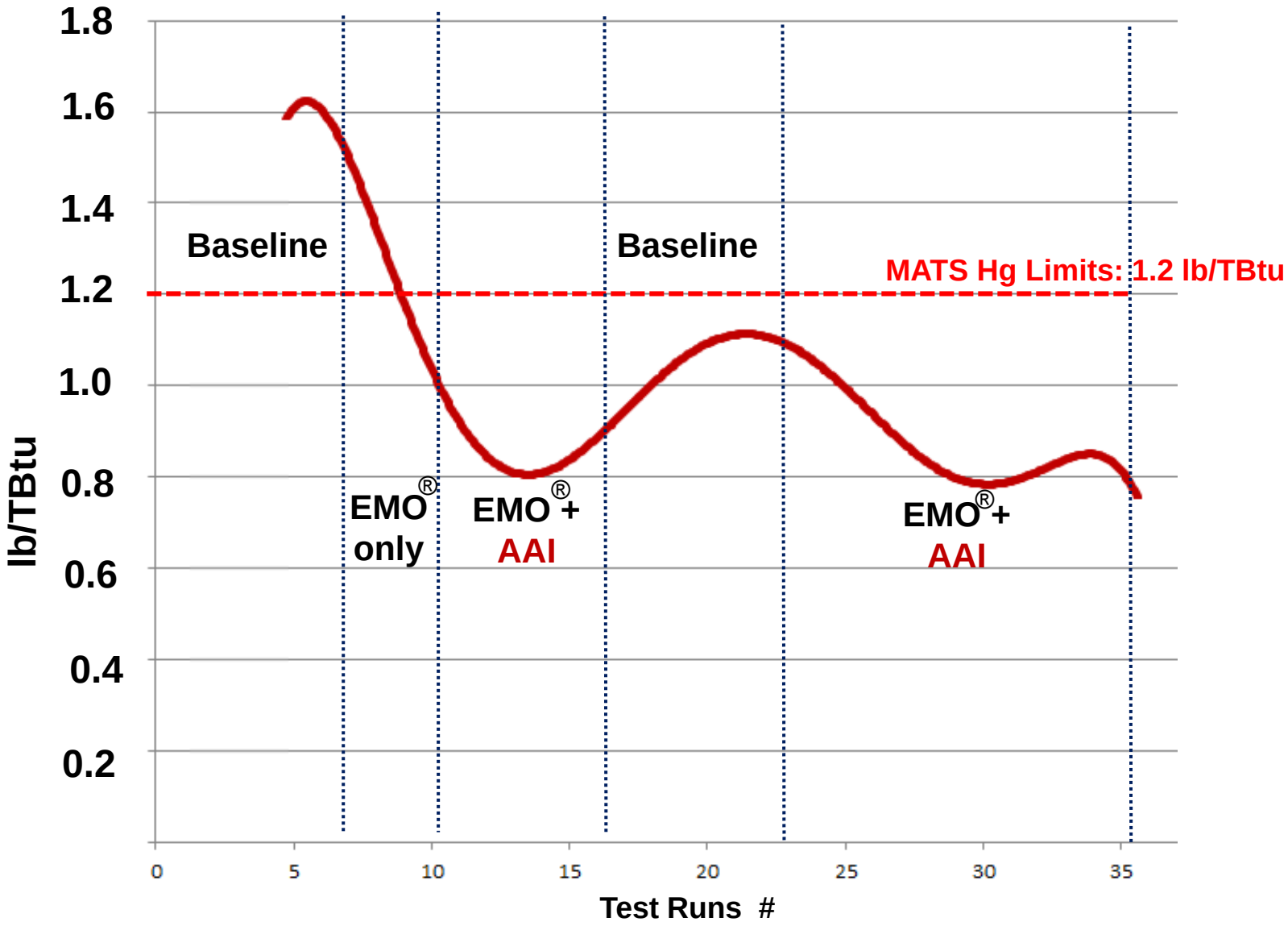
- From various CB&I EMO field trial, SO3 has been observed to inhibit Hg oxidization Hg2+ adsorption across the ESP, and Hg2+ absorption across the FGD

Testing Summary – Reference Unit 4



- **~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 SO_3 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



Can Ca(Br)2 Produce the Same Results? Not Really

Sampling Date	Test Condition	Start Time	End Time	CaBr2 Target	EMO Target	Hydrogen Bromide		Relative Deviation	Hg Oxidization Efficiency	Stack Hg Removal Efficiency
						M26A FGD inlet	M26A Stack			
				ppm	ppmvd	ppmvd	ppmvd	%	%	%
7/12/2012	EMO - Baseline	9:00	10:00	0	0	0.18	0.10		17%	25%
7/12/2012	EMO - Baseline	11:15	12:15	0	0	0.09	0.10		6%	21%
7/12/2012	EMO Parametric	17:00	18:00	0	2.9	4.48	0.10	21%	54%	57%
7/13/2012	EMO Parametric	10:40	11:40	0	5.5	5.78	0.10	3%	71%	60%
7/16/2012	Trona - Baseline	8:00	9:00	260	0	3.27	0.10		61%	51%
7/16/2012	Trona - Baseline	9:30	10:30	260	0	3.47	0.10		61%	50%

✓ 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 Br_2 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 SO_3 emission was observed to inhibit Hg oxidization and oxidized Hg capture across the scrubber - **Hydrated lime injection mitigated SO_3 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)

CONTACT

Bobby I.T. Chen

Client Program Manager

+1 865.670.2687 – Direct

+1 865.360.2823 – Cell

bobby.chen@cbi.com

Randall P. Moore

Business Line Manager

+1 865.694.7455 – Direct

+1 865.604.3945 – Cell

randall.moore@cbi.com