



Shaw® a world of **Solutions**™



EMO™

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Regulatory Updates

- Generally speaking, the Hg(0)/Hg(2+) ratio (native mercury oxidization) at the economizer outlet:
 - Bituminous: 70% Hg(0) / 30% Hg(2+), **12** lb/TBtu in total Hg
 - Sub-bituminous: 90% Hg(0) / 10% Hg(2+), **7** lb/TBtu in total Hg
 - Lignite: 80% Hg(0) / 20% Hg(2+), **30** lb/TBtu in total Hg

Subcategory	Total Filterable Particulate Matter	Hydrogen Chloride	Mercury
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)	1.3 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)

- To reach 90% or above on mercury emission reduction for any coal-fired application

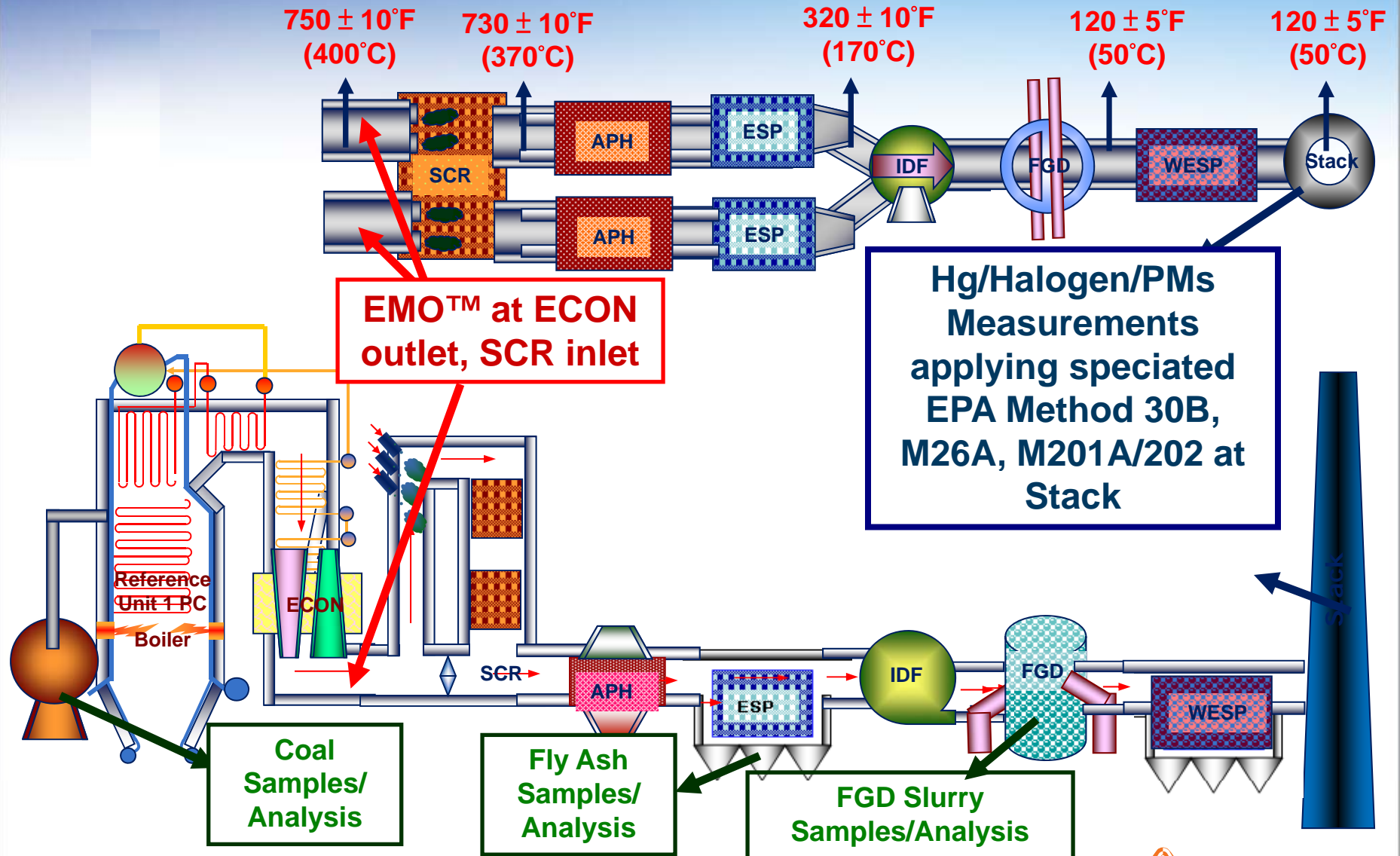
EMO™ Overview / Refresher

- Injection location and temperature: economizer outlet
- Injecting chemical: EMO™ chemical additives
 - Mercury oxidization: $\text{Hg}(0) \rightarrow \text{Hg}(2+)$
 - Mercury absorption/adsorption: with existing ESP, FGD, or to add powdered activated carbon (PAC)

EMO Chemical Injection Process



Reference Unit 1 Testing Arrangements



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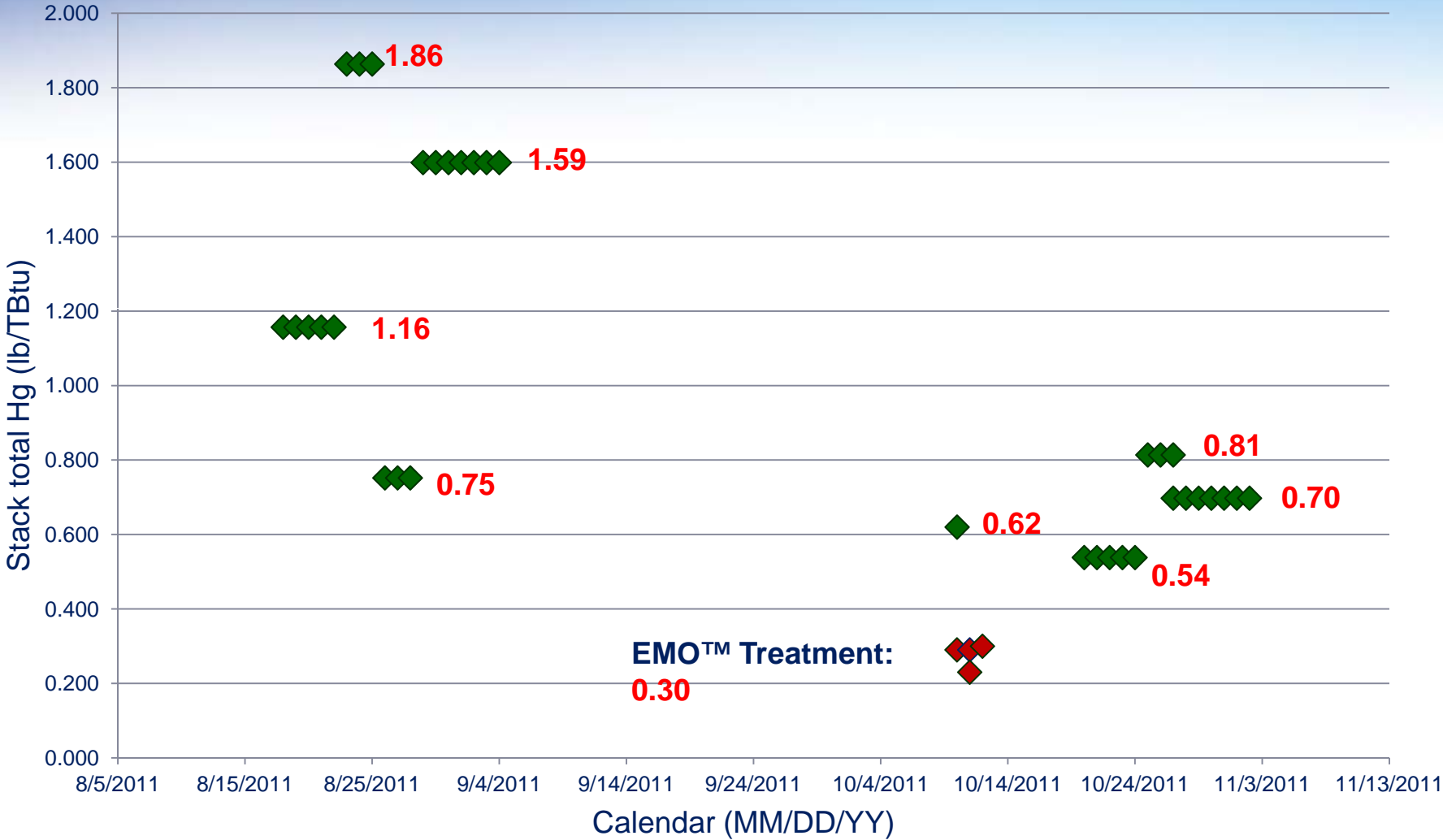
Reference Unit 1 Full Scale Data - Hg

- Unit configuration
 - PC Unit - 300 MW equivalent burning 100% bituminous
 - SCR+ Electric-static precipitator + Wet Scrubber +Wet ESP
- Testing performed
 - Baseline tests, Hg emission determined with speciated sorbent traps
 - Varying EMO™ chemical injection rates at the SCR inlet

Date	Start	End	Unit Load	*Max. Hg From Coal	EMO™ Injection Rate	NH3 Injection Rate	Stack Elemental Hg	Stack Total Hg	Hg Oxidization at Stack	Overall Hg Removal	NOx	FPM (PM CEMs)
mm/dd/yy	HH:MM	HH:MM	(MW)	*(lb/TBtu)	(ppmvd)	(lb/hr)	(lb/TBtu)	(lb/TBtu)	(%)	(%)	(lb/MMBtu)	(lb/MMBtu)
2/25/11	8:45	11:00	305	9.3	0.0	427	0.74	1.71	92.0%	81.6%	0.085	0.002
	11:30	13:30	305	9.3	0.0	416	0.78	1.81	91.6%	80.5%	0.091	0.002
	14:15	16:25	305	9.3	0.0	405	0.66	1.55	92.9%	83.3%	0.095	0.002
10/10/11	8:50	10:50	276	33.9	0.0	395	0.60	0.62	97.2%	97.2%	0.070	0.003
	16:30	18:30	273	33.9	5.2	405	0.26	0.29	98.8%	98.7%	0.078	0.003
10/11/11	10:00	12:00	280	14.1	1.2	480	0.27	0.29	98.8%	98.7%	0.086	0.003
	15:00	17:00	280	14.1	3.0	470	0.21	0.23	99.0%	98.9%	0.081	0.003
10/12/11	10:15	12:15	280	13.1	2.7	471	0.28	0.30	98.7%	98.6%	0.088	0.003

Mercury remission was not observed throughout the entire project

EMO Residual Effects



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Reference Unit 1 Full Scale Data – Halogens

Date	Start	End	Unit Load	Max. Halogen (HCl +Cl ₂)	EMO™ Injection Rate	NH ₃ Injection Rate	Stack HCl*	Stack HBr	Stack HCl*	Stack HBr	Stack Cl ₂	Stack Br ₂
mm/dd/yy	HH:MM	HH:MM	(MW)	(ppmv)	(ppmvd)	(lb/hr)	(lb/MMBtu)	(lb/MMBtu)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)
10/10/11	8:50	10:50	276	103.0	0.0	395	9.04E-09	8.90E-09	0.000060	0.000059	0.000248	0.000093
	16:30	18:30	273	103.0	5.2	405	8.77E-09	8.64E-09	0.000053	0.000052	0.000325	0.000068
10/11/11	10:00	12:00	280	110.5	1.2	480	7.99E-09	7.86E-09	0.000047	0.000047	0.000306	0.000084
	15:00	17:00	280	110.5	3.0	470	7.84E-09	7.72E-09	0.000050	0.000049	0.000299	0.000078
10/12/11	10:15	12:15	280	137.6	2.7	471	9.40E-09	9.26E-09	0.000055	0.000054	0.000332	0.000081

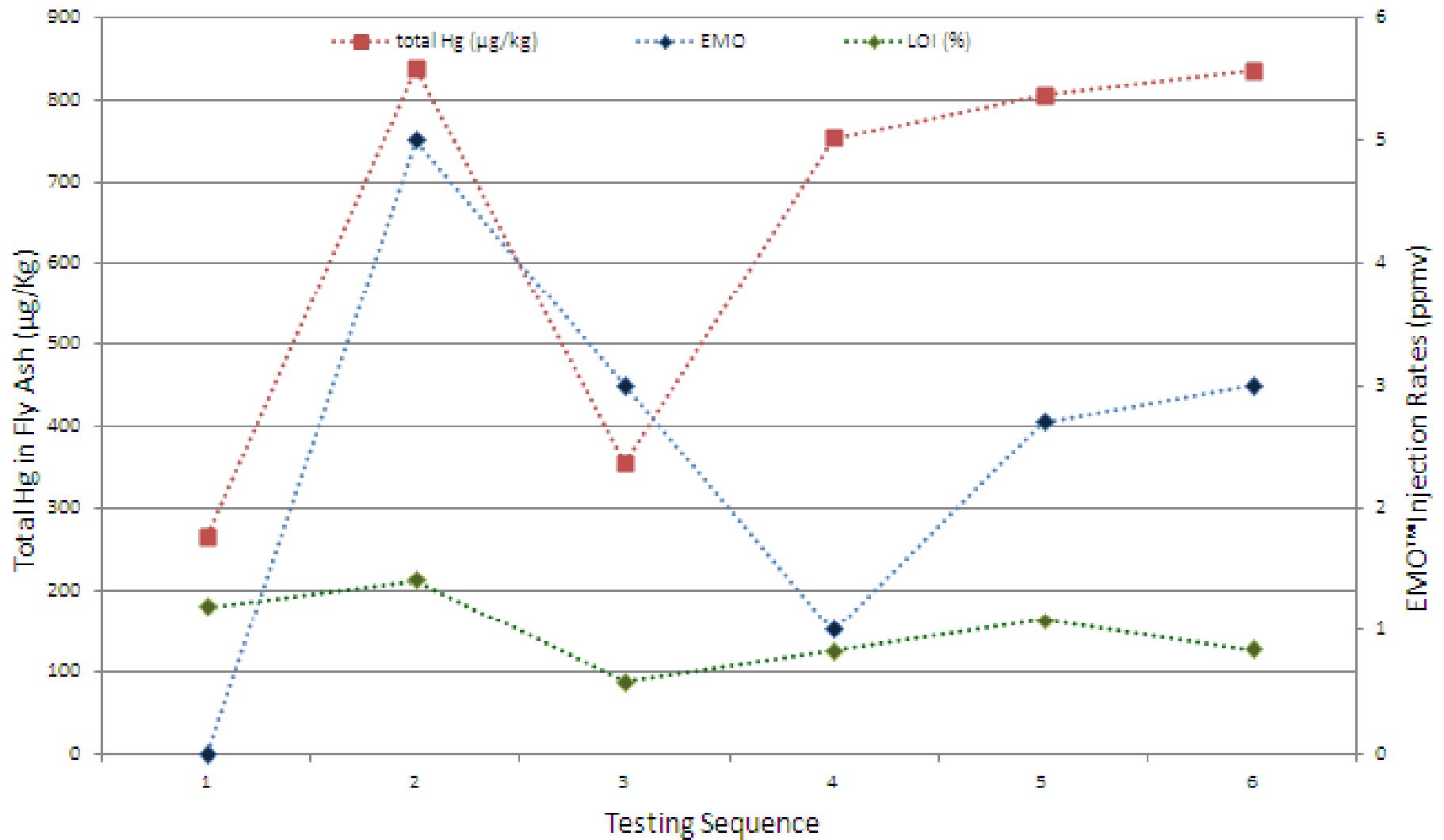
- The stack halogens testing (Cl₂, HCl, Br₂, HBr) determined with EPA method 26A
- All the M26A runs showed successful EGU MACT HCl compliance of 0.002 lb/MMBtu
- The stack Cl₂ emission was observed consistently 500% - 600% higher than the HCl emission
- The EMO™ injection was observed to produce no impact on the stack Br₂ and HBr emissions

Reference Unit 1 Full Scale Data – PMs

Date	Start	End	Unit Load	Max. Halogen (HCl +Cl ₂)	EMO™ Injection Rate	NH ₃ Injection Rate	Stack FPM	Stack CPM	Stack TPM*
mm/dd/yy	HH:MM	HH:MM	(MW)	(ppmv)	(ppmvd)	(lb/hr)	(lb/MMBtu)	(lb/hr)	(lb/MMBtu)
10/10/11	8:50	10:50	276	103.0	0.0	395	0.0111	0.0034	0.0145
	16:30	18:30	273	103.0	5.2	405	0.0088	0.0107	0.0195
10/11/11	10:00	12:00	280	110.5	1.2	480	0.0100	0.0072	0.0172
	15:00	17:00	280	110.5	3.0	470	0.0078	0.0065	0.0144
10/12/11	10:15	12:15	280	137.6	2.7	471	0.0057	0.0083	0.0141

- All the M5/202 runs showed successful EGU MACT TPM compliance of 0.03 lb/MMBtu
- The stack FPM emission improved (decreased) as the EMO™ rate increased
- The stack CPM emission increased as the EMO™ rate increased, but the NH₃ injection also increased

Solid Samples Analyses – Coal/Fly Ash



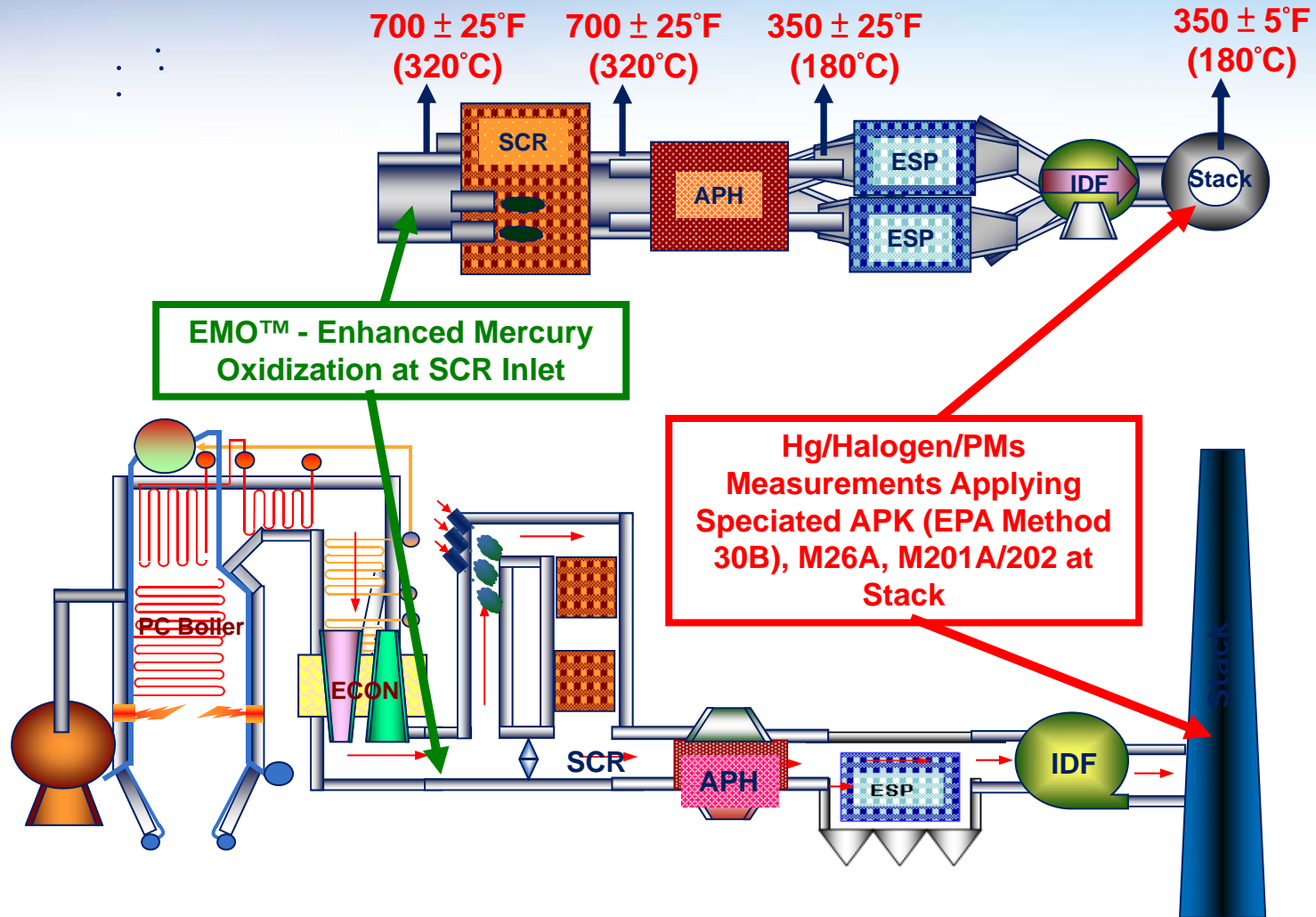
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Solid Samples Analyses – Coal/Fly Ash

Date	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur	Moisture	Ash	Heating Value	Mercury	Chlorine	Bromine	Max. Hg from Coal	Max. Halogen (HCl +Cl ₂)
mm/dd/yy	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(Btu/lb)	(ppm)	(ppm)	(ppm)	(lb/TBtu)	(ppmv)
10/10/11	64.95	4.21	12.33	1.36	2.71	12.18	12.57	10,581	0.33	1200	n/a	33.86	103.01
10/11/11	64.88	4.09	11.11	1.37	2.05	10.99	14.56	10,541	0.14	1300	n/a	14.11	110.46
10/12/11	64.74	4.40	13.84	1.40	2.32	11.92	11.58	10,750	0.13	1600	n/a	13.12	137.61
Average	64.86	4.23	12.43	1.38	2.36	11.70	12.90	10,624	0.20	1,367	n/a	20.36	117.03
Maximum	64.95	4.40	13.84	1.40	2.71	12.18	14.56	10,750	0.33	1,600	n/a	33.86	137.61
Minimum	64.74	4.09	11.11	1.36	2.05	10.99	11.58	10,541	0.13	1,200	n/a	13.12	103.01
Variation	0.2%	3.7%	10.9%	1.4%	13.8%	5.1%	11.4%	1.0%	43.6%	14.3%	n/a	44.2%	14.4%

Client sample ID:	FA-1 101011 AM	FA-2 101011 PM	FA-3 101111 AM	FA-4 101111 PM	FA-5 101211 AM	FA-5 101211 PM
Testing Conditions	Baseline	Parametric EMO™ 5 ppmv	Parametric EMO™ 1 ppmv	Parametric EMO™ 3 ppmv	Parametric EMO™ 3 ppmv	Parametric EMO™ 3 ppmv
Total Mercury, µg/Kg	266	752	838	356	805	835
Total Chlorine (ppm)	600	100	400	100	200	100
total Bromine (ppm)	n/a	n/a	n/a	n/a	n/a	n/a
LOI (%)	1.20	0.83	1.42	0.58	1.09	0.84
TCLP Chromium, µg/l	* 5,000	6.3	6.4	14.0	20.1	10.2
TCLP Arsenic, µg/l	* 5,000	55.0	65.0	151.0	52.4	156.0
TCLP Selenium, µg/l	* 1,000	20.7	24.7	69.1	11.3	63.6
TCLP Silver, µg/l	*5,000	<5.0	<5.0	<5.0	<5.0	<5.0
TCLP Cadmium, µg/l	*1,000	26.0	5.7	<5.00	18.5	<5.00
TCLP Barium, µg/l	* 100,000	127.0	166.0	112.0	243.0	120.0
TCLP Mercury, µg/l	* 200	<0.5	<0.5	<0.5	<0.5	<0.5
TCLP Lead, µg/l	* 5,000	<5.0	<5.0	<5.0	<5.0	<5.0

Reference Field Trial Unit Configuration

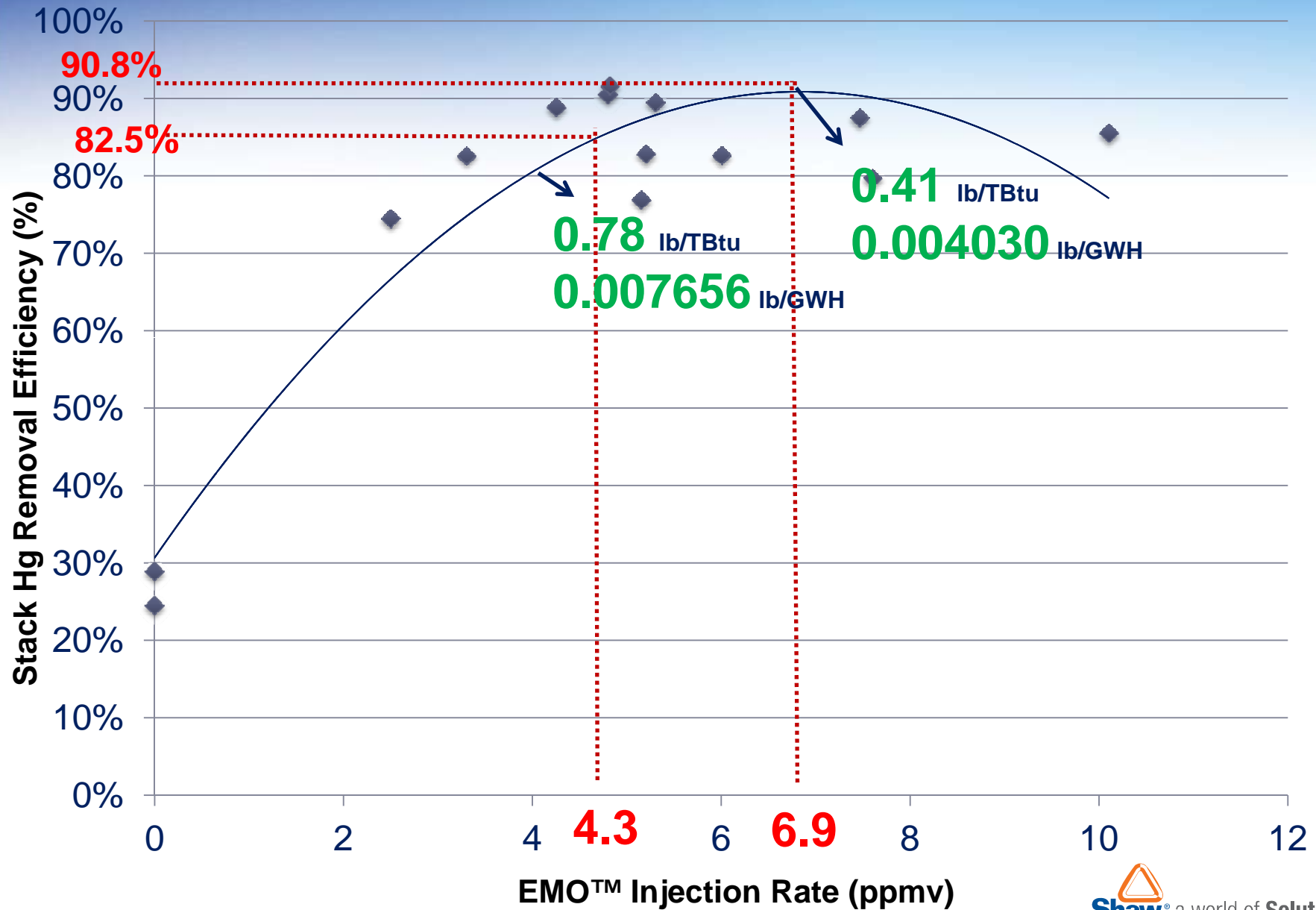


Reference EMO™ Full Scale Data

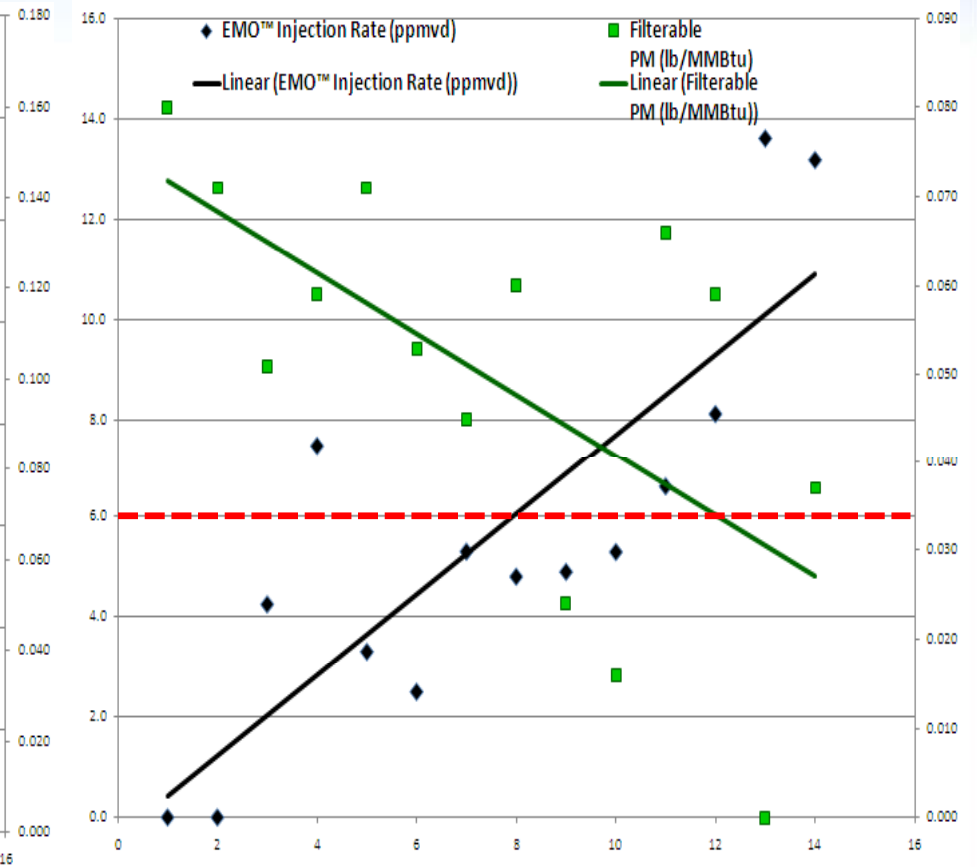
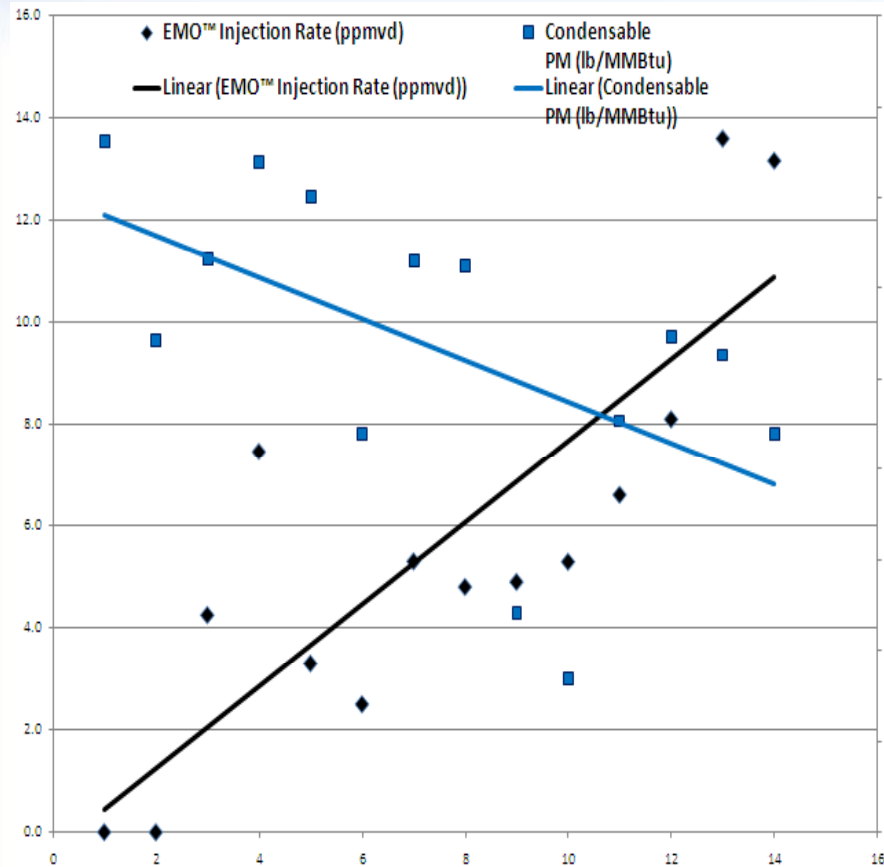
- Unit configuration
 - PC Unit - 340 MW equivalent burning 100% PRB
 - SCR+ electric-static precipitator
- Testing performed
 - Baseline tests
 - Varying EMO™ chemical injection rates at the economizer outlet

Date	Unit Load	PRB blending by Weight	Max. Hg From PRB	EMO™ Injection Rate	PAC Injection Rate	SO3 Injection Rate	NH3 Injection Rate	Stack Hg	Stack Hg	Hg Oxidization at Stack	Overall Hg Removal	NOx	Opacity
mm/dd/yy	(MW)	(%)	(lb/TBtu)	(ppmvd)	(lb/mmcf)	(ppmvd)	(lb/hr)	(lb/TBtu)	(lb/GWh)	(%)	(%)	(lb/MMBtu)	(%)
5/2/11	329	100.0%	7.0	0.0	0	4	223	3.20	0.03122	0.0%	54.3%	0.044	23.9
	329	100.0%	7.0	0.0	0	4	216	3.40	0.03317	0.0%	51.4%	0.042	23.7
5/3/11	338	100.0%	7.0	7.6	0	4	232	0.91	0.00888	82.7%	87.0%	0.043	19.0
	338	100.0%	7.0	5.2	0	0	236	0.77	0.00751	81.5%	89.0%	0.045	17.4
	338	100.0%	7.0	10.1	0	0	250	0.65	0.00634	85.8%	90.7%	0.045	15.0
5/4/11	348	100.0%	7.0	4.3	0	0	252	0.50	0.00488	87.6%	92.9%	0.045	17.0

Result Overview – Hg Reduction at Stack



EMO™ Data Overview (Particle Matters, FPM/CPM)

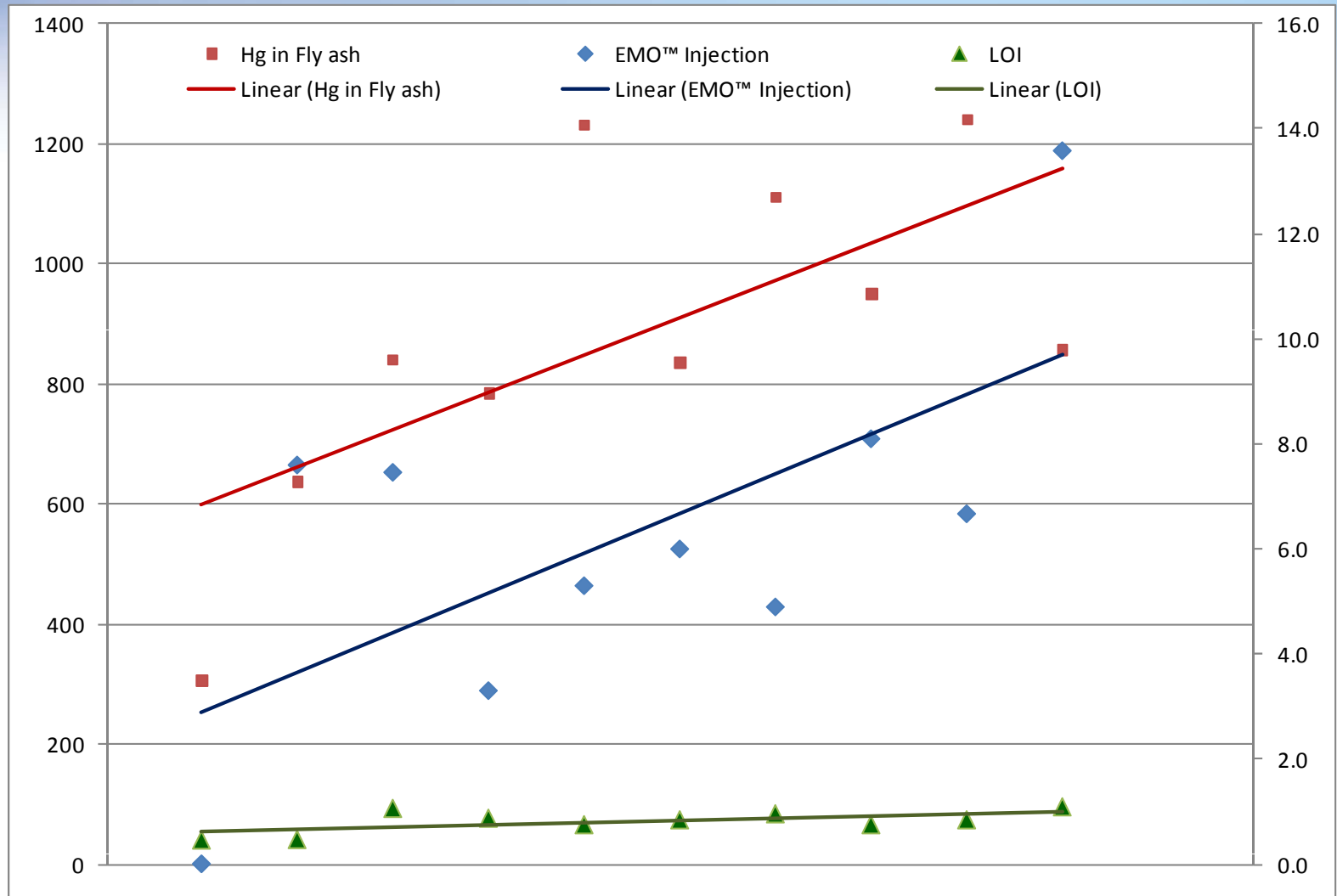


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Fly Ash Hg Analysis

Sample ID	Analyte	Report Matrix	LOI (%)	Result	Units
X-031911	Hg	Baseline	0.03	0.046	mg/Kg
X-032011	Hg	EMO-Parametric	0.03	0.104	mg/Kg
X-032111	Hg	EMO-Parametric	0.03	0.132	mg/Kg
X-032211	Hg	EMO-Optimal	0.06	0.251	mg/Kg
X-032311	Hg	EMO-Optimal	0.06	0.147	mg/Kg
Y-033011	Hg	Baseline	0.48	0.069	mg/Kg
Y-033111	Hg	Baseline	0.22	0.074	mg/Kg
Y-040111	Hg	EMO-Parametric	0.34	0.234	mg/Kg
Y-040211	Hg	EMO-Parametric	0.34	0.261	mg/Kg
Y-040311	Hg	EMO-Optimal	0.41	0.334	mg/Kg
Z-001	Hg	Baseline	<0.01	0.014	mg/Kg
Z-002	Hg	EMO-Parametric	<0.01	0.406	mg/Kg
Z-003	Hg	EMO-Parametric	<0.01	0.481	mg/Kg
Z-004	Hg	EMO-Optimal	<0.01	0.489	mg/Kg

Hg Content in the Fly Ash vs. EMO™

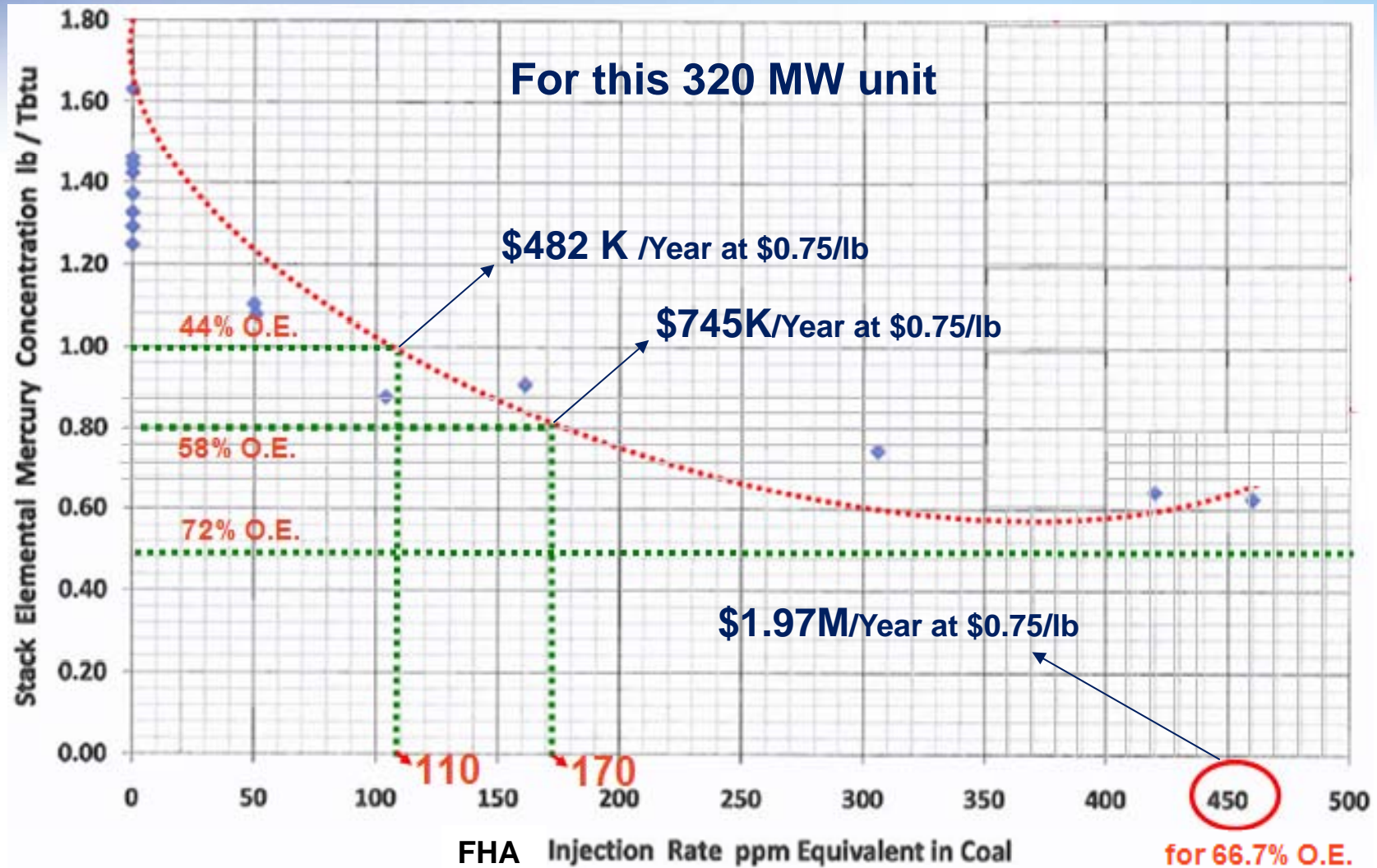


TCLP Analysis

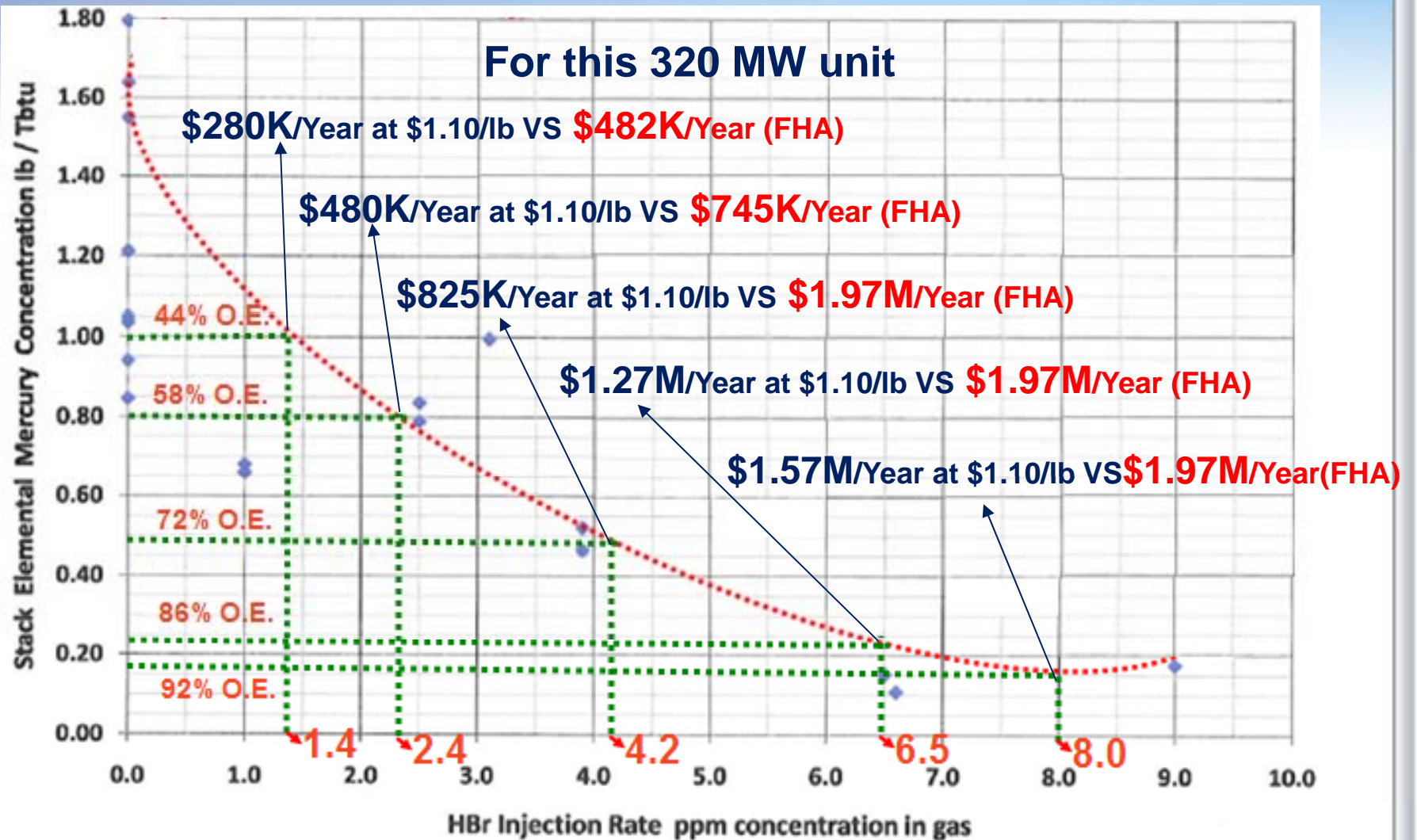
Sample ID	Condition	Sample Date	Hg	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver
			mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
X-031911	Baseline	3/19/2011	BRL	BRL	0.69	BRL	0.143	BRL	0.0615	BRL
X-032011	EMO-Parametric	3/20/2011	BRL	BRL	0.719	BRL	0.14	BRL	0.0566	BRL
X-032111	EMO-Parametric	3/21/2011	BRL	BRL	0.791	BRL	0.12	BRL	0.0638	BRL
X-032211	EMO-Optimal	3/22/2011	BRL	BRL	0.893	BRL	0.276	BRL	0.0994	BRL
X-032311	EMO-Optimal	3/23/2011	BRL	BRL	0.923	BRL	0.111	BRL	0.0899	BRL
Y-033011	Baseline	3/30/2011	BRL	BRL	0.715	0.0131	0.0577	BRL	0.0686	BRL
Y-033111	Baseline	3/31/2011	BRL	0.0248	1.38	BRL	0.0125	BRL	0.075	BRL
Y-040111	EMO-Parametric	4/1/2011	BRL	BRL	2.34	BRL	BRL	BRL	0.0793	BRL
Y-040211	EMO-Parametric	4/2/2011	BRL	0.0226	0.925	BRL	0.0425	BRL	0.132	BRL
Y-040311	EMO-Optimal	4/3/2011	BRL	0.0406	0.0571	BRL	0.0651	BRL	0.303	BRL
Z-001	Baseline	4/11/2011	BRL	0.349	0.793	BRL	0.235	BRL	1.24	BRL
Z-002	EMO-Parametric	4/12/2011	BRL	0.154	2.21	BRL	0.0201	BRL	0.454	BRL
Z-003	EMO-Parametric	4/13/2011	BRL	0.598	0.611	BRL	0.554	BRL	0.751	BRL
Z-004	EMO-Optimal	4/14/2011	BRL	0.559	0.833	BRL	0.612	BRL	0.609	BRL
Z-005	EMO-Optimal w/ACI	4/15/2011	BRL	0.424	0.82	BRL	0.49	BRL	0.536	BRL
Z-006 ESP	Baseline	4/11/2011	BRL	0.0863	2.41	BRL	0.0972	BRL	0.419	BRL
Z-007 ESP	EMO-Parametric	4/12/2011	BRL	0.126	2.38	BRL	0.219	BRL	0.377	BRL
Z-008 ESP	EMO-Parametric	4/13/2011	BRL	0.0238	0.183	BRL	BRL	BRL	0.0905	BRL
Z-009 ESP	EMO-Optimal	4/14/2011	BRL	0.14	2.19	BRL	0.0789	BRL	0.442	BRL
Z-010 ESP	EMO-Optimal w/ACI	4/15/2011	BRL	0.0833	2.08	BRL	0.0605	BRL	0.428	BRL
Limits			Hg	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver
			Regulated Level (mg/l) or (ppm)	0.2	5	100	1	5	5	1

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FHA Performance on Hg Oxidization

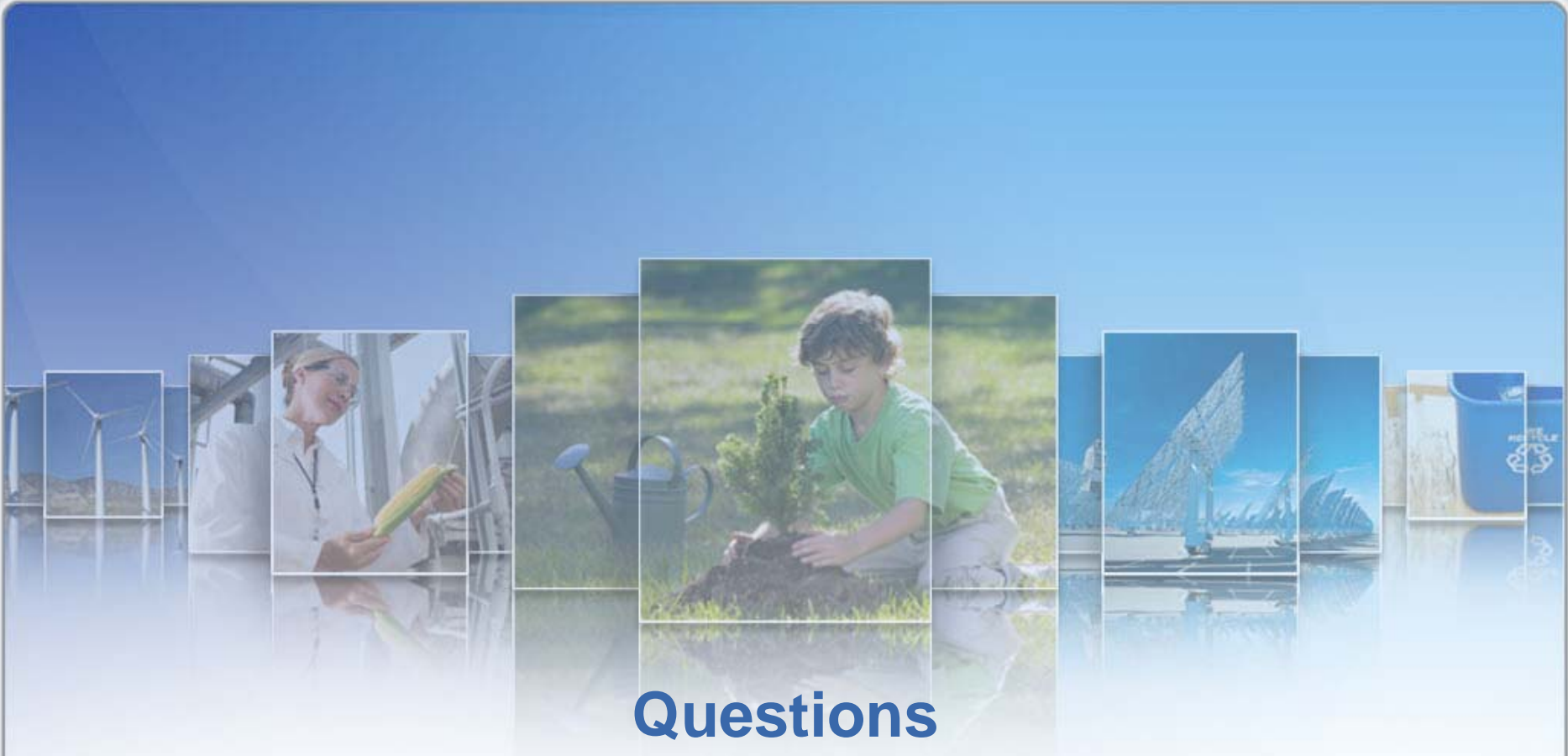


EMO™ Performance on Hg Oxidization



Conclusions & Recommendations

- ✓ EMO™ Injection successfully demonstrated Hg compliance to the final EPA EGU MACT (>90% plus stack Hg oxidization and Hg removal efficiency)
- ✓ EMO™ improved the stack FPM. It was actually applied to replace SO3 for the fly ash conditioning
- ✓ EMO™ injection does not create fly ash disposal problems (No metal leaching issues observed)
- ✓ Some applications require a combination of EMO and PAC for efficient Hg control and to be cost-effective



Questions

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