Multi-pollutant Emission Reduction Technology for Small Utility Boilers

Nalco Mobotec

Presented to:

Lake Michigan Air Directors Consortium

Innovative Industrial Source Control and Measurement Technologies Workshop

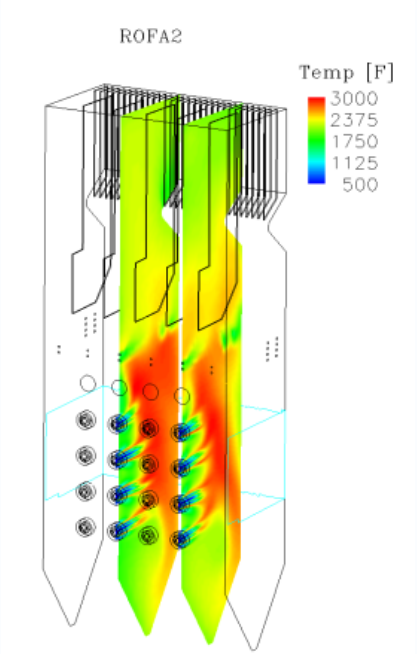
March 24, 2010

Multi-pollutant Control Approach

- NOx
- SO_2
- SO_3
- Mercury
- HCl
- Combustion efficiency improvement
- CO_2 – biomass co-firing

Nalco Mobotec Systems

- ROFA® System– NOx, Combustion Improvement, LOI, PM
- Rotamix® System - NOx, SOx, Hg, HCl
- Sorbent Injection Systems – SO_2 sorbents, activated carbon
- MerControl® - Hg
- 8034 Chemical - Hg
- MagMill® – Multi-pollutant, combustion improvement, slagging reduction, plant efficiency
- Co-firing Biofuels
- Biomass Conversion Projects
- Fireside Chemicals



Multi-pollutant Control Approach

- ROFA
  - Rotating Opposed Fired Air System
  - Deep combustion staging
  - High turbulence for mixing
  - CFD modeling
  - NOx, SO_3 reductions

U.S. ROFA System Installations

Plant	Location	Installation	Chemical	Load	Fuel	Boiler Type
CP&L, Cape Fear Unit 5	USA	ROFA/Rotamix	Ammonia	154MW	Pulverized Coal	T-fired Single
CP&L, Cape Fear Unit 6	USA	ROFA/Rotamix	Ammonia	172MW	Pulverized Coal	T-fired Twin
Dynegy, Vermillion	USA	ROFA/Rotamix	Urea	80MW	Pulverized Coal	T-fired Single
Richmond, Whitewater 1	USA	ROFA/Rotamix	Ammonia	44 MW	Pulverized Coal	Wall fired
Richmond, Whitewater 2	USA	ROFA/Rotamix	Ammonia	72 MW	Pulverized Coal	T-fired
Dominion, Yorktown 1	USA	ROFA/Rotamix	Ammonia	175 MW	Pulverized Coal	T-fired Twin
Dominion, Chesapeake 1	USA	ROFA/Rotamix	Ammonia	120 MW	Pulverized Coal	T-fired
Dominion, Chesapeake 2	USA	ROFA/Rotamix	Ammonia	120 MW	Pulverized Coal	T-fired
Dominion, Bremo Bluff 4	USA	ROFA	Air Only	165 MW	Pulverized Coal	Wall fired
*Northeast	USA	ROFA/Rotamix	Ammonia	180 MW	Pulverized Coal	Wall fired
*Northeast	USA	ROFA/Rotamix	Ammonia	180 MW	Pulverized Coal	Wall fired
*Midwest	USA	ROFA	Air Only	160 MW	Pulverized Coal	Wall fired
*Northeast	USA	ROFA/Rotamix	Ammonia	570 MW	Pulverized Coal	Opposed-fired
AMP, Gorsuch 3	USA	ROFA	Air Only	55 MW	Pulverized Coal	Wall fired
AMP, Gorsuch 2	USA	ROFA	Air Only	55 MW	Pulverized Coal	Wall fired
City of Glendale, Grayson 5	USA	ROFA/Rotamix	Ammonia	44 MW	Land-fill Gas	Wall fired
Dominion, Yorktown 2	USA	ROFA/Rotamix	Ammonia	175 MW	Pulverized Coal	T-fired Twin
Progress Energy, Robinson	USA	ROFA	Air Only	172 MW	Pulverized Coal	T-fired twin
Richmond, Whitewater 2	USA	Rotamix FSI	Limestone	72 MW	Pulverized Coal	T-fired
Progress Energy, Sutton 3	USA	Enhanced Rotamix	Urea	424 MW	Pulverized Coal	Wall fired

U.S. ROFA System Installations

Plant	Location	Installation	Chemical	Load	Fuel	Boiler Type
Georgia Pacific, Cedar Springs PB1	USA	ROFA	Air Only	530,000lbs/hr	Wood/Coal	Grate & Wall Fired
Georgia Pacific, Cedar Springs PB2	USA	ROFA	Air Only	530,00lbs/hr	Wood/Coal	Grate & Wall Fired
Inter-Power/AhlCon Partners - Colver Power Project	USA	ROFA	Air Only	131 MW	Waste Coal	Circ. Fluidized Bed
New Energy Capital, Greenville Energy Center	USA	ROFA/Rotamix	Urea	17 MW	Wood	Bubbling Bed
Minnesota Power, Taconite Harbor Unit 2	USA	ROFA/Rotamix/FSI	Urea, Lime, MercControl	75 MW	Pulverized Coal	T-Fired
Solutia	USA	ROFA/FSI	MinPlus	40MW	Pulverized Coal	Wall fired
EnGeneration - Lumberton Unit 1	USA	ROFA/FSI	Limestone	16MW	Coal	Stoker
EnGeneration - Lumberton Unit 2	USA	ROFA/FSI	Limestone	16MW	Coal	Stoker
EnGeneration - Elizabethtown Unit 1	USA	ROFA/FSI	Limestone	16MW	Coal	Stoker
EnGeneration - Elizabethtown Unit 2	USA	ROFA/FSI	Limestone	16MW	Coal	Stoker
Progress Energy - Lee 3	USA	Enhanced Rotamix	Urea	260 MW	Pulverized Coal	Wall fired
Nevada Power, Reid Gardner Unit 4	USA	ROFA	Air Only	260MW	Pulverized Coal	Wall fired
Smurfit Stone Container Corp - Ontonagon	USA	ROFA/FSI	MinPlus	29MW	Pulverized Coal	Wall fired
Minnesota Power, Taconite Harbor Unit 1	USA	ROFA/Rotamix/FSI	Urea, Lime, MercControl	75 MW	Pulverized Coal	T-Fired
Minnesota Power, Taconite Harbor Unit 3	USA	ROFA/Rotamix/FSI	Urea, Lime, MercControl	75 MW	Pulverized Coal	T-Fired
AES Beaver Valley - Unit 3	USA	ROFA	Air Only	43 MW	Pulverized Coal	Wall fired
Altura Power/PSNM - Twin Oaks Power Unit 1	USA	ROFA	Air Only	175 MW	Lignite	Circ. Fluidized Bed
Altura Power/PSNM - Twin Oaks Power Unit 2	USA	ROFA	Air Only	175 MW	Lignite	Circ. Fluidized Bed
Hoosier Energy Unit 1	USA	ROFA/FSI	Limestone	130 MW	Pulverized Coal	Wall fired
Rochester Public Utility	USA	ROFA/Rotamix	Urea	50 MW	Pulverized Coal	Wall fired

U.S. ROFA System Installations

Plant	Location	Installation	Chemical	Load	Fuel	Boiler Type
Minnesota Power, Boswell Unit #1	USA	ROFA/Rotamix	Urea	73 MW	Pulverized Coal	Wall fired
Minnesota Power, Boswell Unit #2	USA	ROFA/Rotamix	Urea	73 MW	Pulverized Coal	Wall fired
Minnesota Power, Boswell Unit #4	USA	Enhanced Rotamix	Urea	565 MW	Pulverized Coal	T-fired
Confidential Client	USA	ROFA/Rotamix	Urea	20 MW	Coal	Grate
Primary Energy/EPCOR Southport, Unit #1, Blr #1	USA	ROFA/FSI	Limestone	20 MW	Wood/Coal/TDF	Grate
Primary Energy/EPCOR Southport, Unit #1, Blr #2	USA	ROFA/FSI	Limestone	20 MW	Wood/Coal/TDF	Grate
Primary Energy/EPCOR Southport, Unit #1, Blr #3	USA	ROFA/FSI	Limestone	20 MW	Wood/Coal/TDF	Grate
Primary Energy/EPCOR Southport, Unit #2, Blr #1	USA	ROFA/FSI	Limestone	20 MW	Wood/Coal/TDF	Grate
Primary Energy/EPCOR Southport, Unit #2, Blr #2	USA	ROFA/FSI	Limestone	20 MW	Wood/Coal/TDF	Grate
Primary Energy/EPCOR Southport, Unit #2, Blr #3	USA	ROFA/FSI	Limestone	20 MW	Wood/Coal/TDF	Grate
Primary Energy/EPCOR Roxboro, Unit #1, Blr #1	USA	ROFA/FSI	Limestone	20 MW	Wood/Coal/TDF	Grate
Primary Energy/EPCOR Roxboro, Unit #1, Blr #2	USA	ROFA/FSI	Limestone	20 MW	Wood/Coal/TDF	Grate
Primary Energy/EPCOR Roxboro, Unit #1, Blr #3	USA	ROFA/FSI	Limestone	20 MW	Wood/Coal/TDF	Grate
Confidential Client	USA	FSI	MinPlus	300 MW	Coal	T-Fired
Confidential Client	USA	FSI	MinPlus	400 MW	Coal	T-Fired
Hoosier Energy Unit 2	USA	ROFA/FSI	Limestone	130 MW	Pulverized Coal	Wall fired
** For Individual Project Results Please Contact a MobotecUSA Representative						

Mobotec Multi-Pollutant Control in CAIR, BART

Mobotec as in December 29, 2005 Federal Register/Proposed Rules

Several technology options are available for mitigating sulfuric acid emission increases from CAIR retrofit projects.

These include:

- Injecting alkali materials into the furnace;
- Injecting alkali post furnace;
- Injecting ammonia;
- Fuel switching (e.g., firing lower sulfur coal);
- Selecting specialized SCR catalyst with a low SO3 conversion rate;
- Installing wet ESP; and
- Installing FGD.

The Agency anticipates that some CAIR sources may choose to install emerging multi-pollutant control technologies designed to reduce not only SO2 and NOX but SO3 and other pollutants as well. Generally, sources choosing to employ such technologies would do so if they found it to be economical. Although EPA does not endorse the purchase or sale of any specific products and services mentioned, example multi-pollutant technologies include:

- Powerspan ECO Technology; and
- Mobotec USA Inc. ROTAMIX

December 29, 2005 Federal Register

Federal Register/Proposed Rules

- The affected CAIR sources also have the option to use an advanced OFA system with the potential to achieve high NOX reduction levels, with no increases in CO and unburned carbon levels. This technology utilizes rotating opposed fire air (ROFA) and has been installed or demonstrated at several plants worldwide.[15] [foot note to Nalco Mobotec website]

BART

Mobotec BART in Minnesota (page 14 of the state's acceptance)

Given that the Mobotec technology is the most cost effective as compared with the alternative technology considered, and given the desirability associated with reducing NOx, SO2 and mercury with one technology application, the MPCA views the selection of the Mobotec technology as a cost-effective reduction strategy for Taconite Harbor and meets the requirements of the statute.

Summary

The Taconite Harbor retrofit project meets the conditions of Minn. Stat. 216B.1692, subd 1, lowering emission rates of regulations pollutants to substantially lower than applicable NSPS for SO2 and mercury and at an overall cost-effective level for all pollutants. No change in PM emissions will occur with implementation of this project.

NOx Control

ROFA® System

Rotating Opposed Fire Air

Before ROFA

After ROFA

ROTAMIX® System

A THIRD GENERATION SNCR

NOx Removal Chemical Equations

NOx Reduction

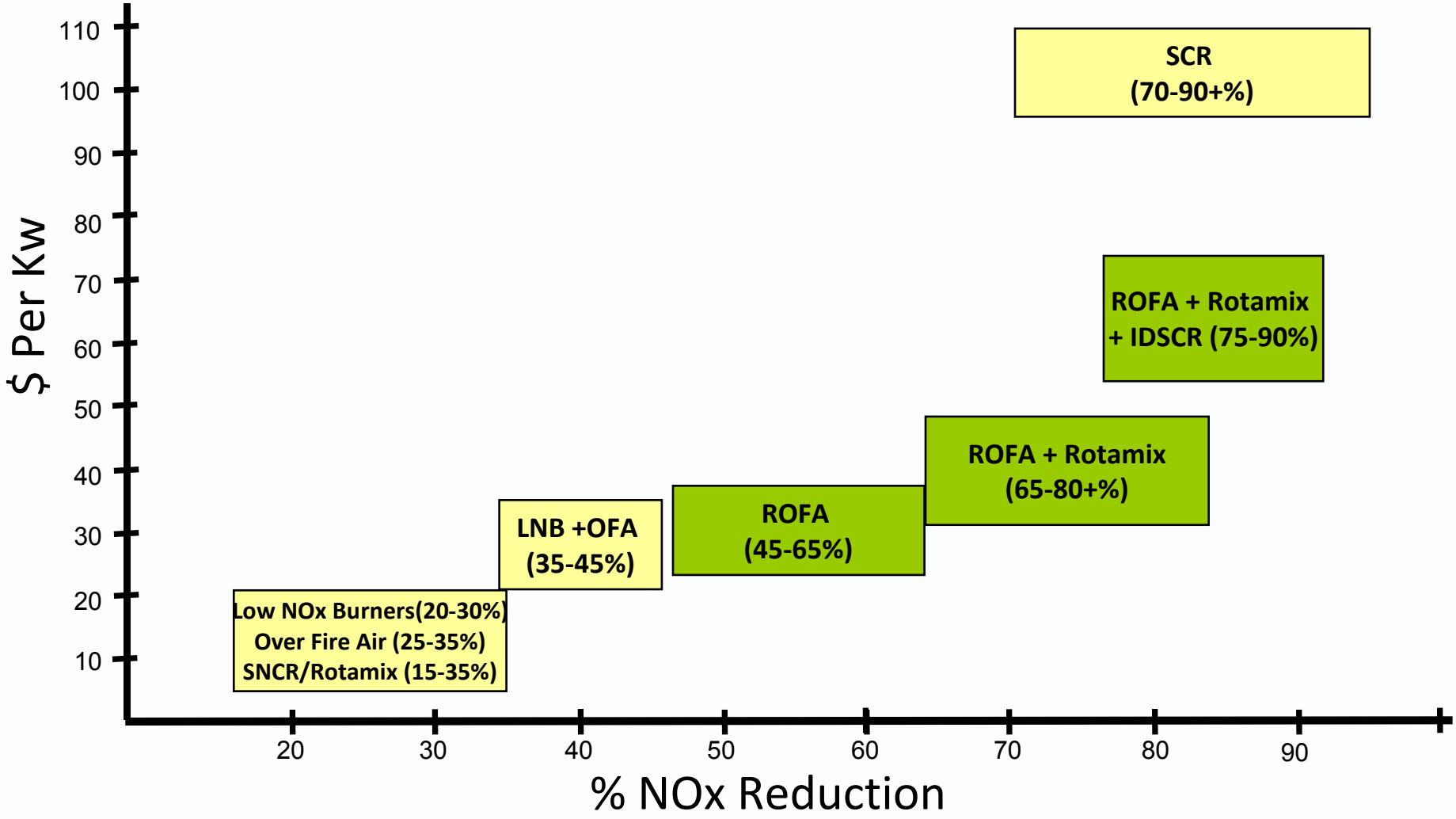
- Ammonia

  $4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$

- Urea

  $2NO + (NH_2)_2CO + {}^1/_2O_2 \rightarrow 2N_2 + 2H_2O + 2CO_2$

NOx Reduction Technology



Sorbent Injection Systems for SO_2, SO_3 and Hg

Multi-pollutant Control Approach

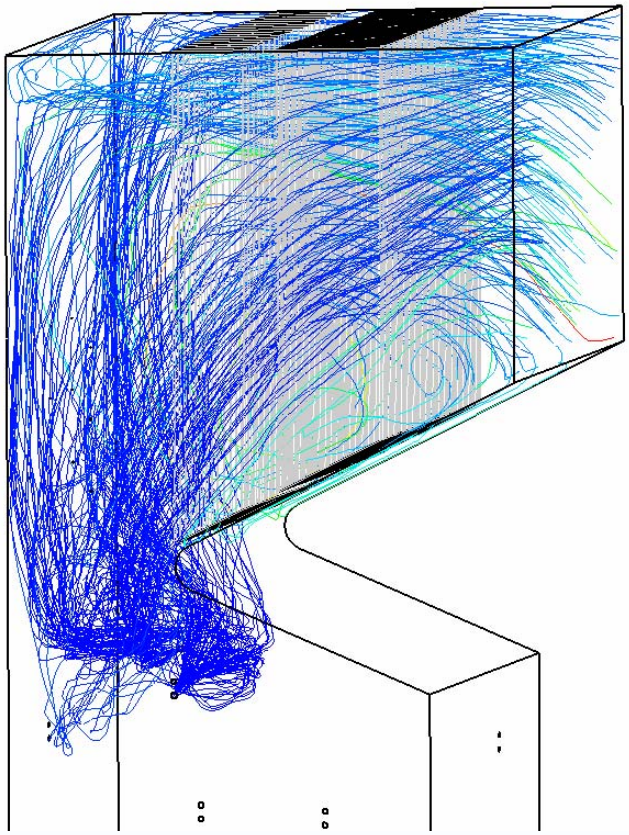
- ROFA System
  - High turbulence for mixing
  - CFD modeling
  - NOx, SO_3 reductions
- ROFA + Rotamix SO_2 Control
  - Furnace sorbent injection
  - High turbulence ideal for SO_2 capture
  - CFD modeling to target optimum injection temperature

Sorbent Injection through ROFA Ports

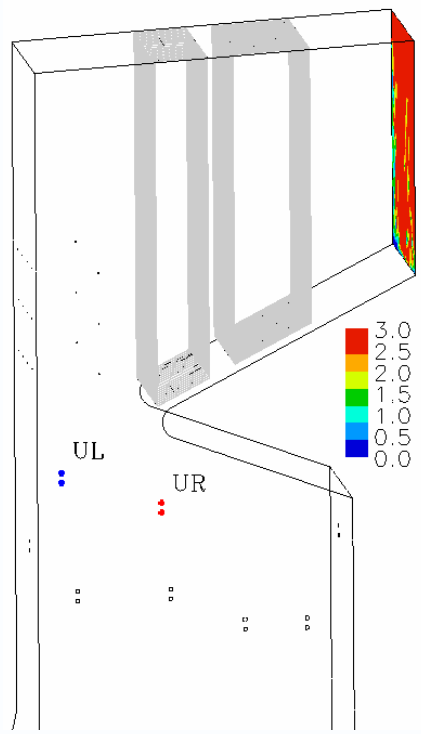
SO_2 Control Technologies

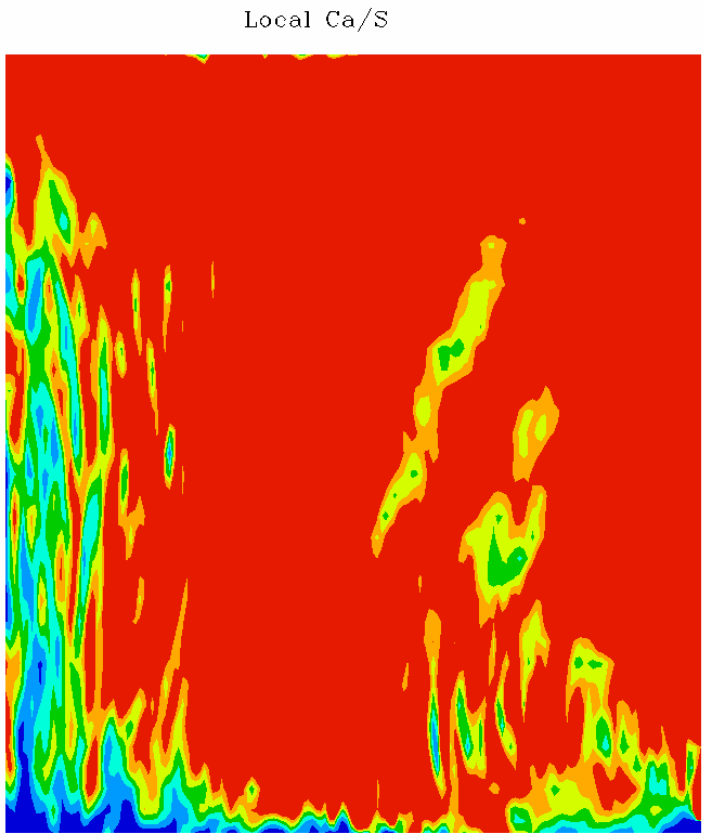
- Furnace sorbent injection (FSI)
  - Hydrated lime or limestone
  - 50-70% SO_2 reduction
- Post-furnace sorbent injection (DSI)
  - Trona or sodium bicarbonate
  - 60-80% SO_2 reduction
- Applicable to low to medium sulfur coals, including PRB

Furnace Sorbent Injection Modeling

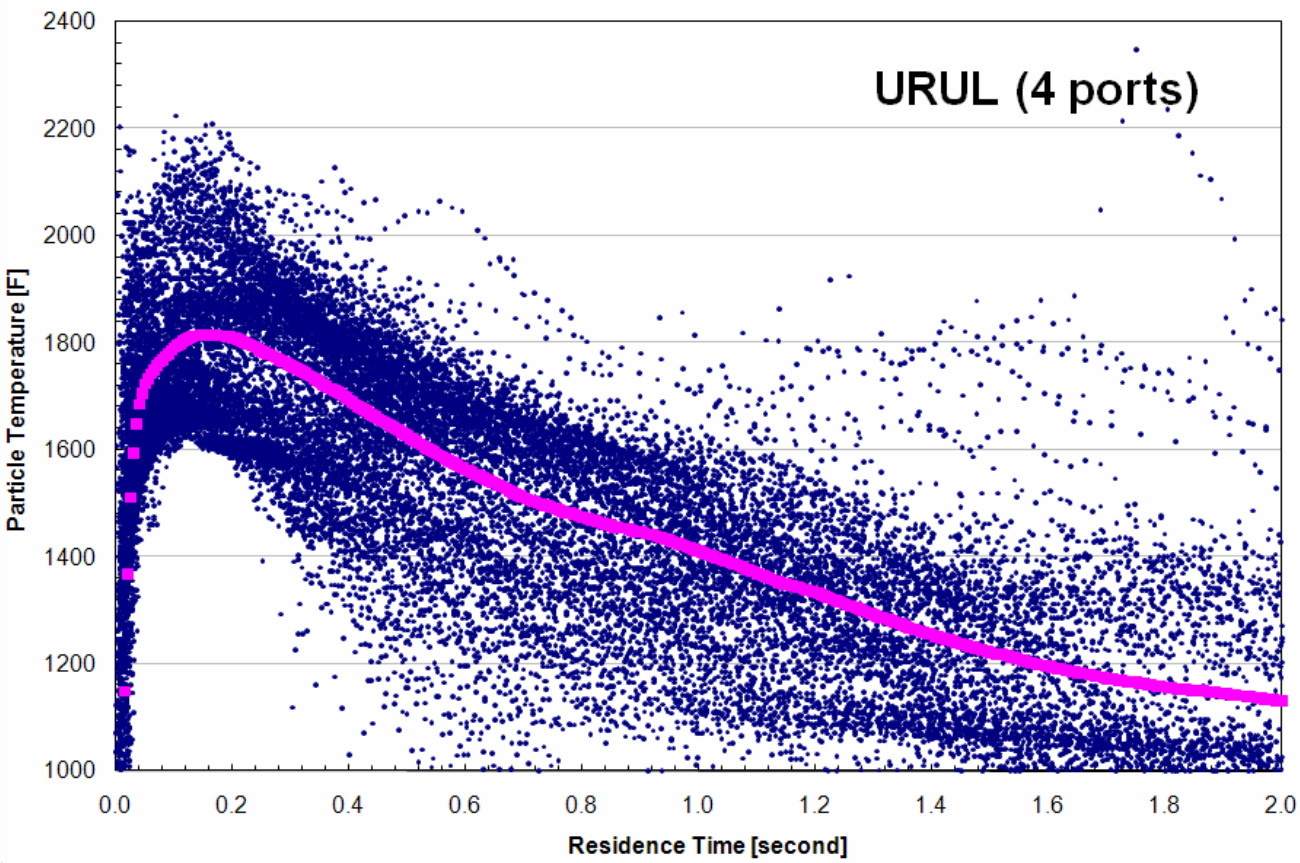


Sorbent Distribution Optimized





Sorbent Temperature/Time Optimized



FSI SO_2 Control at EGU's

Company	Unit	State	MW
Minnesota Power	Taconite Harbor Units 1&2	MN	150
Richmond Power & Light	Whitewater Valley Unit 2	IN	72
EnGeneration	Lumberton Units 1&2	NC	32
EnGeneration	Elizabethtown Units 1&2	NC	32
EPCOR	Roxboro	NC	57
EPCOR	Southport	NC	114
TOTAL			**457**

DSI SO_2 Control at EGU's

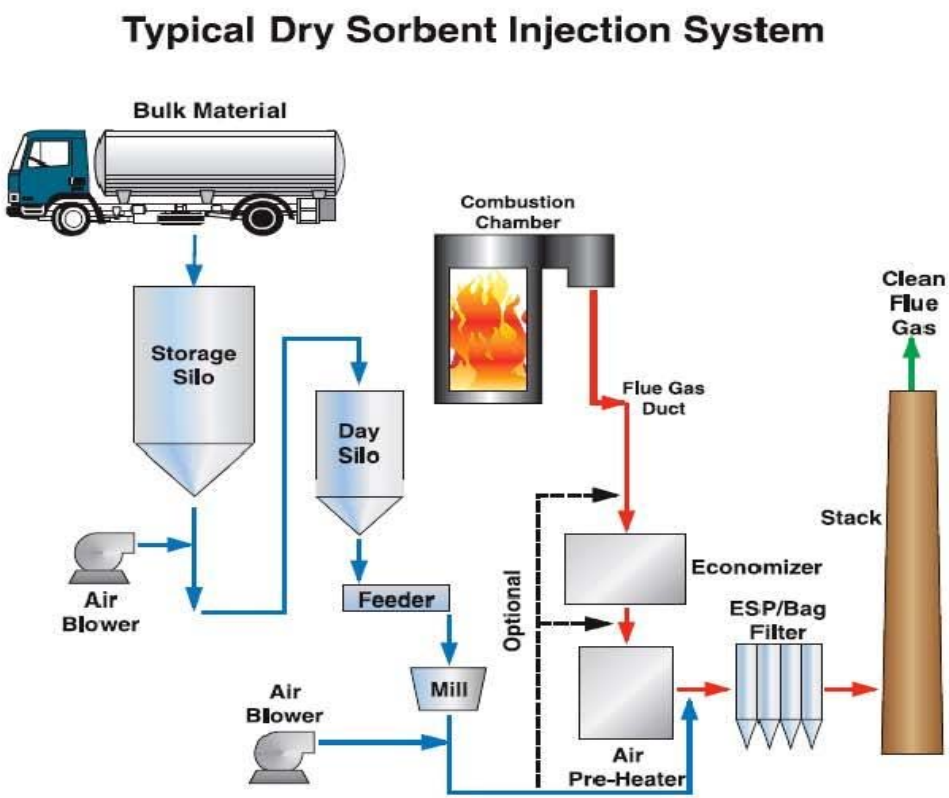
Company	Unit	State	MW
Conectiv Energy	Edge Moor Units 3&4	DE	252
NRG Energy	Huntley Units 67&68	NY	435
NRG Energy	Dunkirk Units 1-4	NY	514
Mirant	Potomac River Units 1-5	VA	628
TOTAL			**1829**

Sorbent Injection Systems Available

- **Full Scale Permanent systems for Trona (milled and unmilled)**
- **Full Scale Permanent systems for Hydrate Injection**
- **Full Scale Permanent systems for Limestone Furnace Injection**
- **Full Scale Permanent systems for ACI Injection**
- **Trona Injection testing**
- **Sodium Bicarbonate Injection testing**
- **Sodium Sesquicarbonate Injection testing**
- **Hydrate Injection Testing**
- **ACI Injection testing**

Full-scale Sorbent Injecting Testing Equipment

Permanent Injection Systems



Mercury Control

Mercury Control Solutions

Coal Enrichment

Sorbent Injection

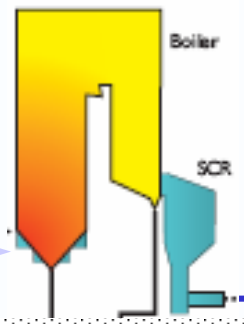
FGD Additives

Hg^T

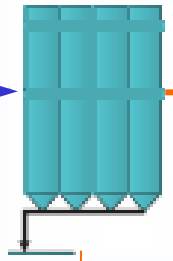
Coal

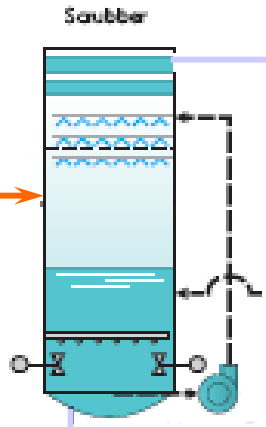
MagMill™

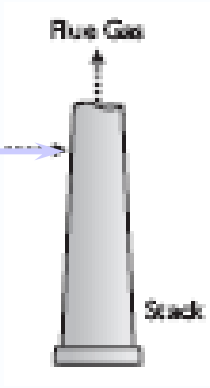
Boiler



PMD







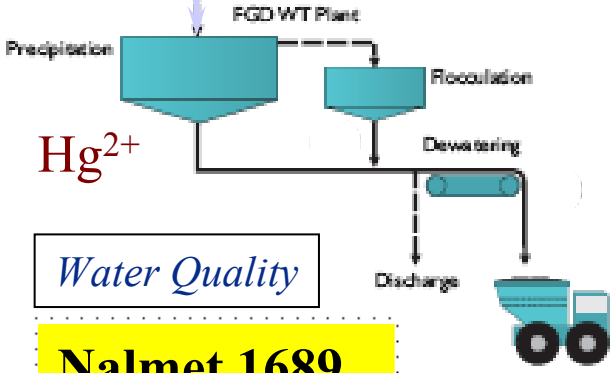
MerControl® 7895

Activated Carbon

Fly Ash/Hg

MerControl® 8034

Waste Water/Contaminants



Hg^{2+}

Water Quality

Nalmet 1689

$Hg^T = Hg^0 + Hg^{2+}$ + particulate Hg

Nalco Mobotec Offerings

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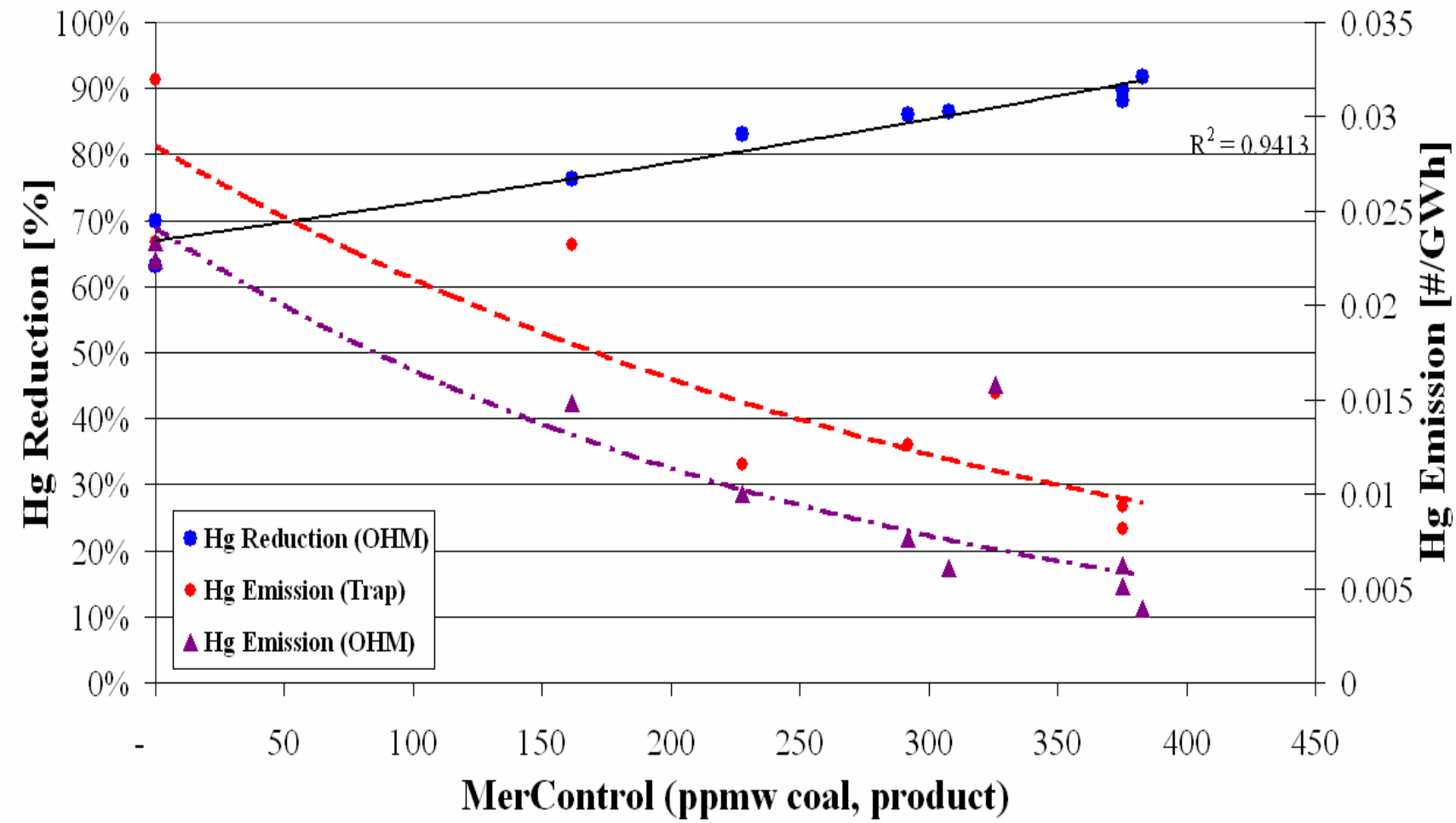
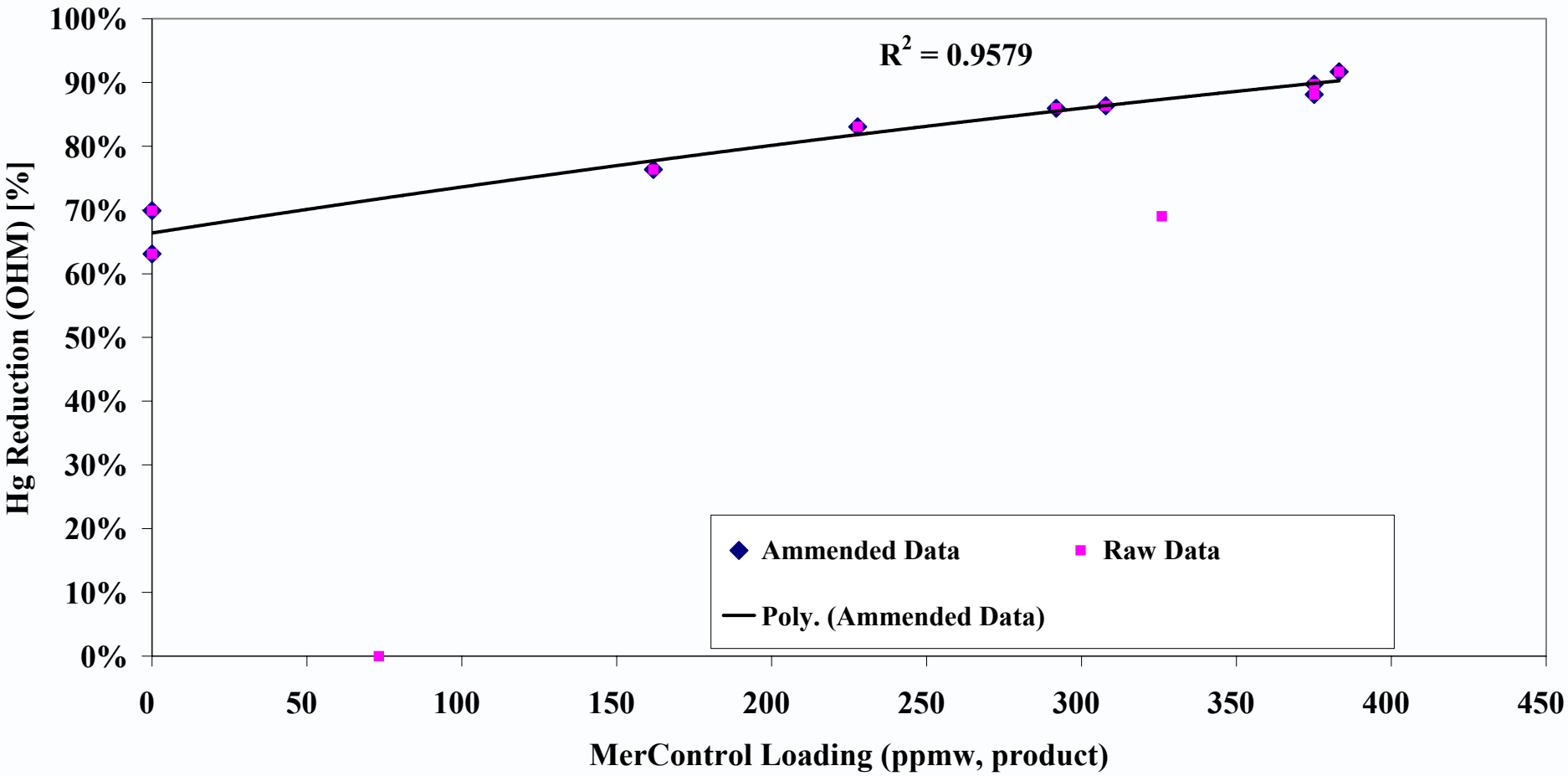
Factors Influencing MerControl® 7895 Efficiency

- Percent Carbon present in fly ash
- Percent Native Hg Oxidation
- Halogen Present in Coal
- Influence of SCR
- Presence of W-FGD
- Primary Mechanism of Removal
  - ACI vs. FGD

MerControl® 7895 Case 1: Bituminous Coal (High Cl), SCR, CS-ESP, W-FGD



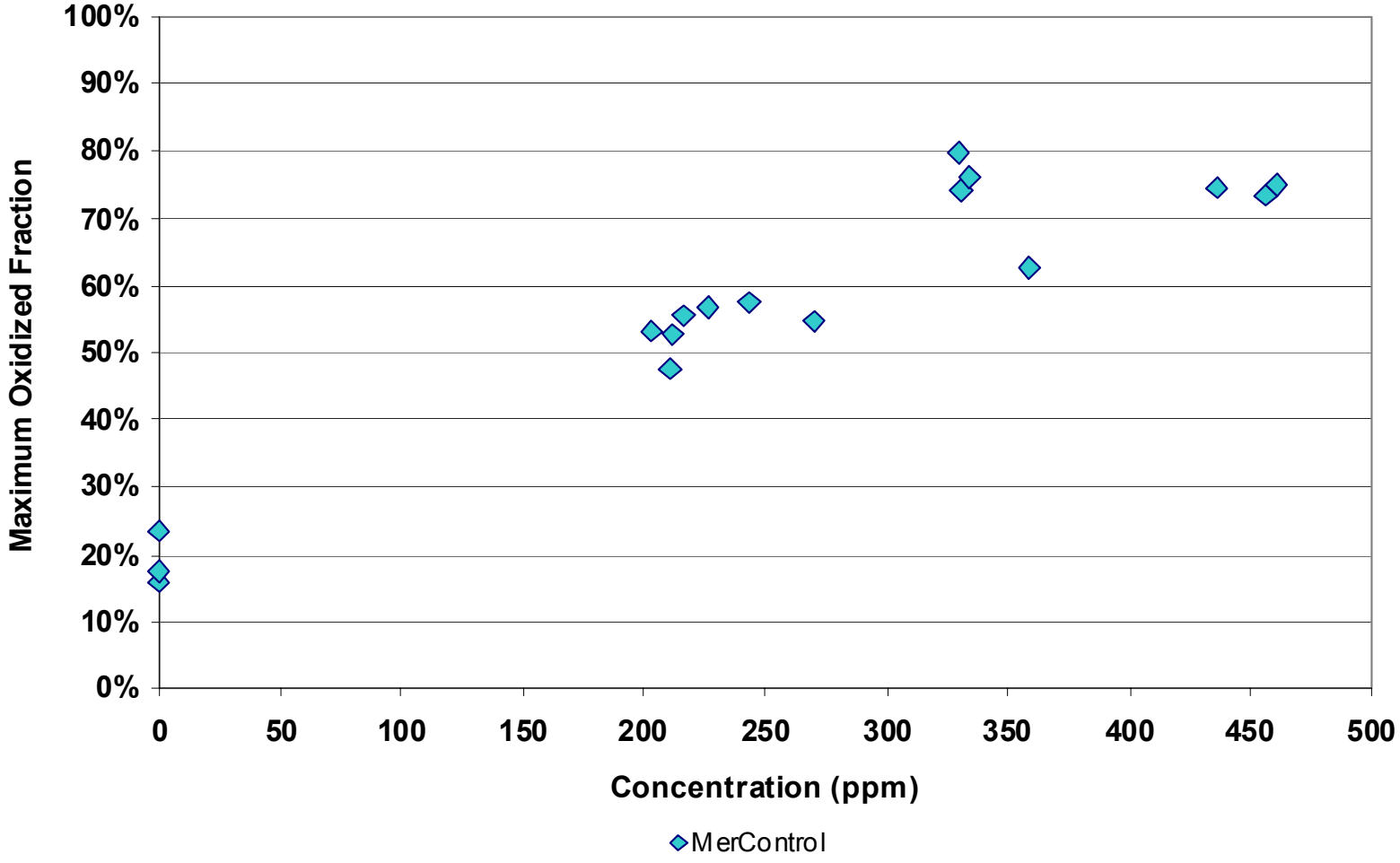
MerControl® Case 1: Bituminous Coal (High Cl), SCR, CS-ESP, W-FGD



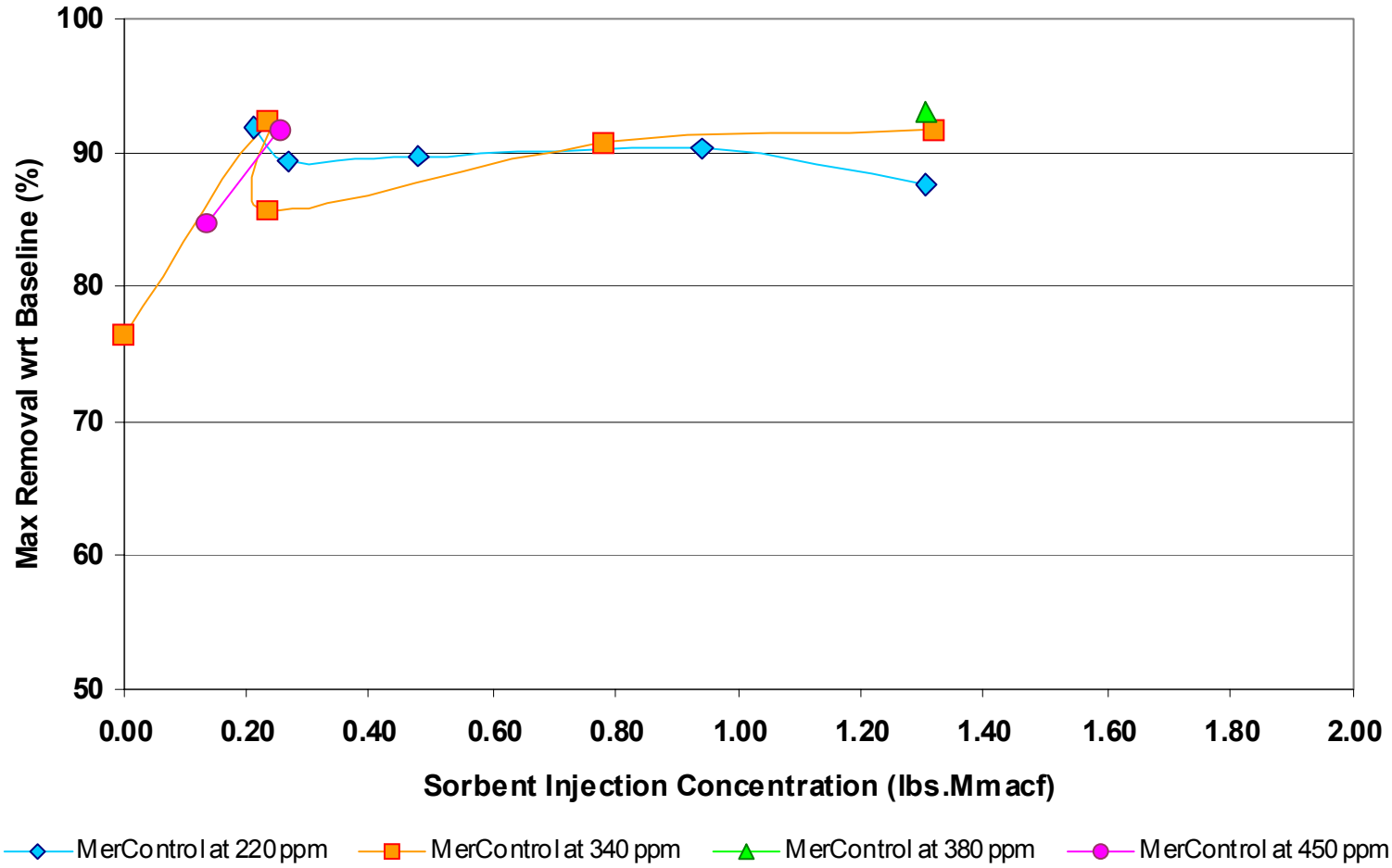
MerControl® 7895 plus PAC injection: Case 2

- 180 MW Combined (Two Units)
- Sub-bituminous
- Cold-side ESP
- Combined Fabric Filter
- Testing performed in conjunction with EPRI (mercury sampling performed by Apogee Scientific)
- Evaluated performance of MerControl® 7895 with straight PAC injection compared to halogenated sorbents.
- Also, included modified non-halogenated carbon with MerControl® 7895.

MerControl® 7895 plus PAC (Sub, CS-ESP, FF): Case 2

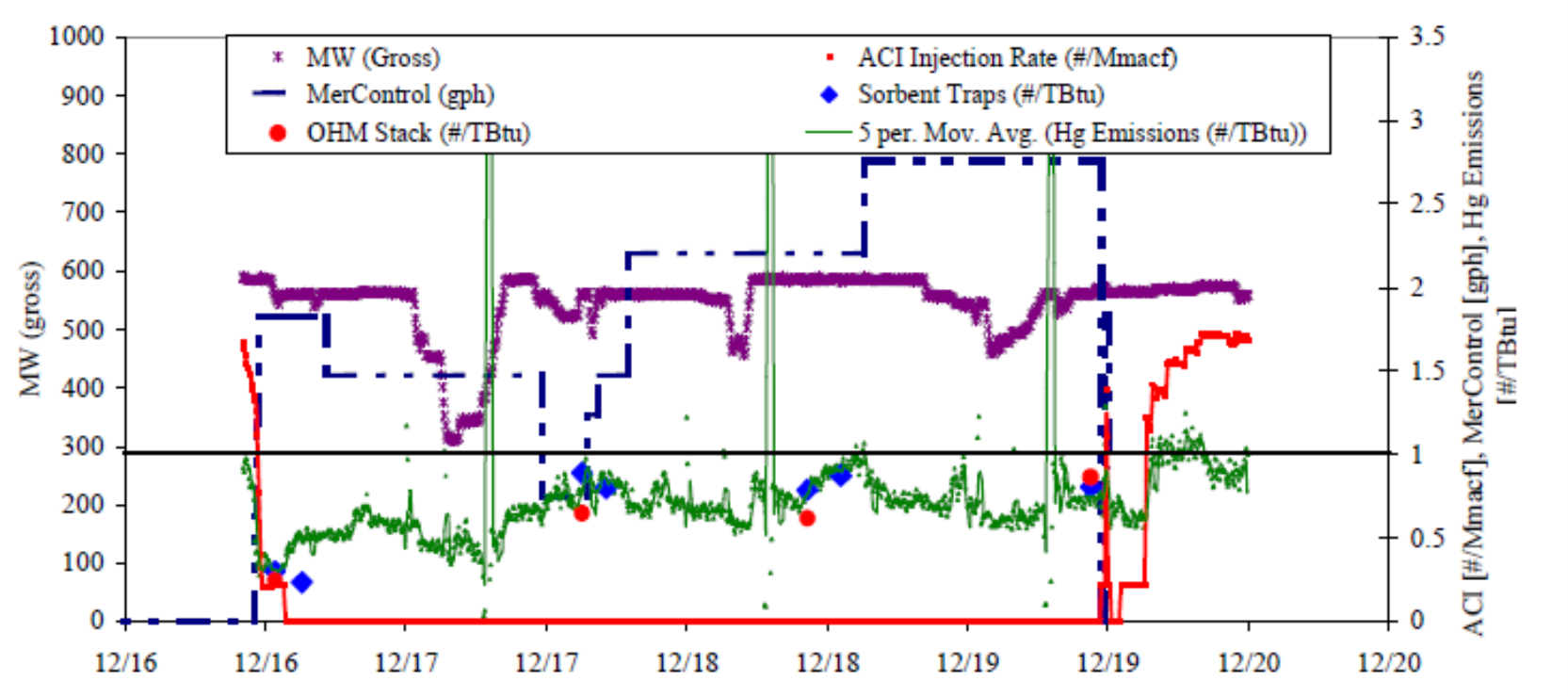


MerControl® 7895 plus PAC (Sub, CS-ESP, FF): Case 2

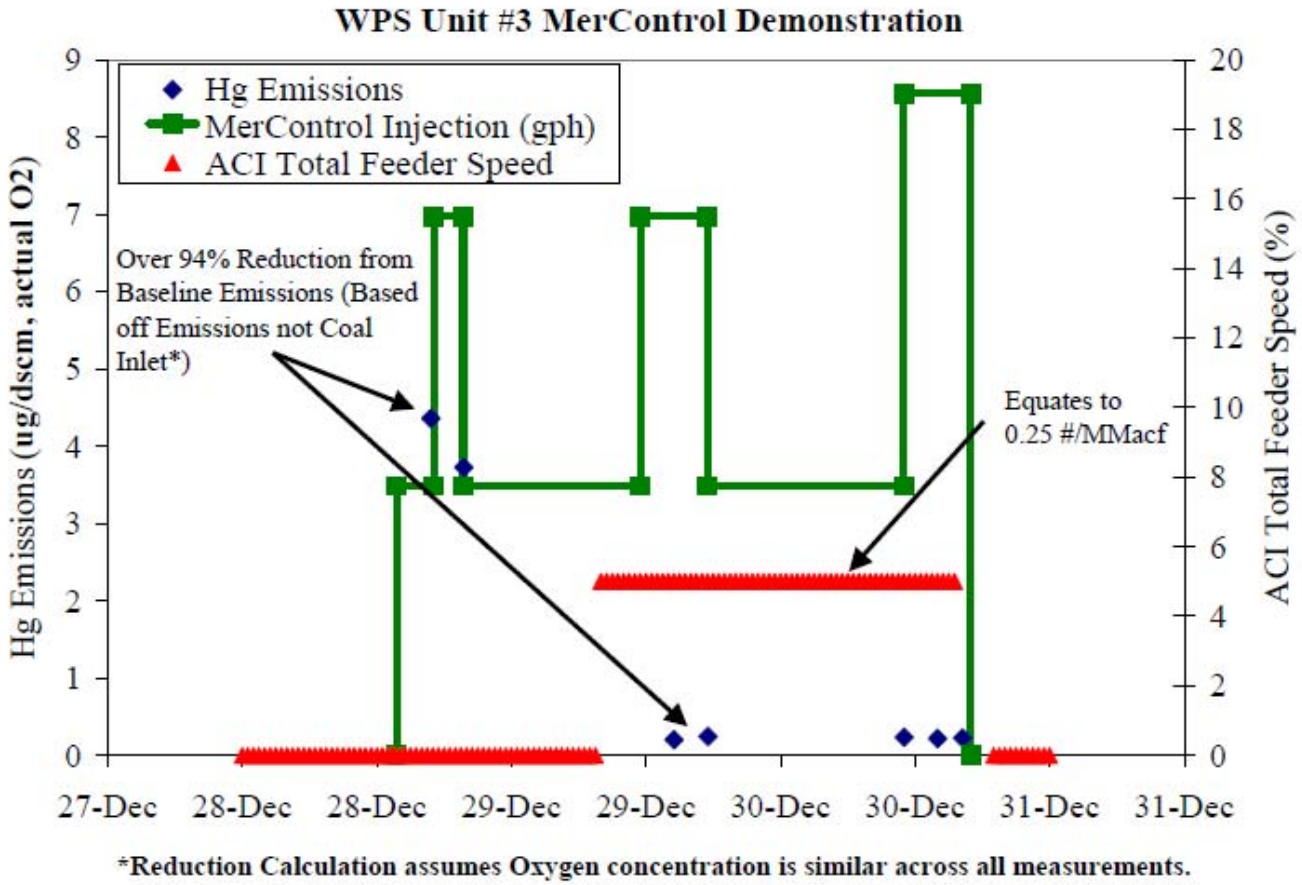


MerControl® 7895 plus HPAC (Sub, SCR, SDA, FF): Case 3

Existing - 1.5 lbs/MMACF of HPAC to get 1.7 lbs/TBtu Hg
MerControl – 0 lbs/MMACF of HPAC, 2.8 gph MerControl to get 0.7 lbs.TBtu Hg



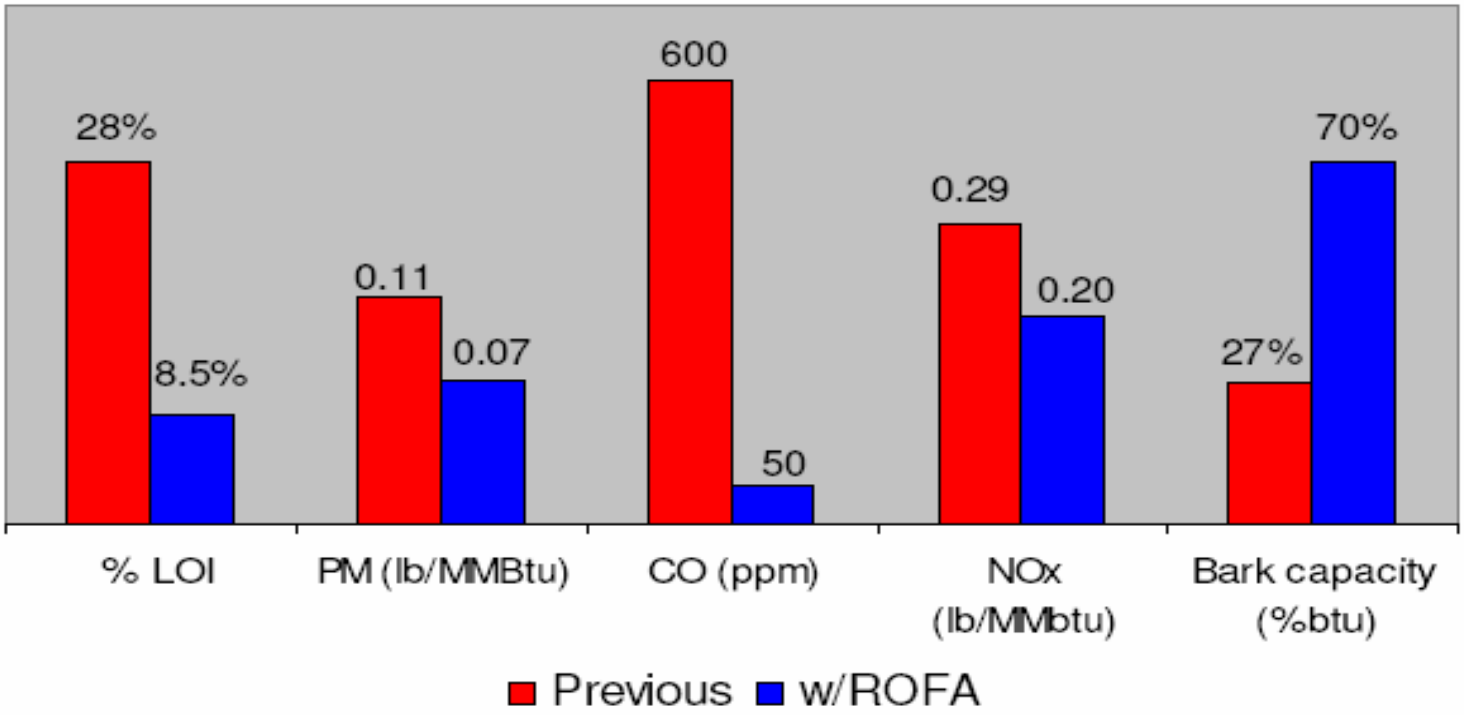
MerControl® 7895 plus PAC (Sub, CS-ESP): Case 4



Biomass and Biomass Co-firing

USA Paper Mill (550,000lbs/hr)
Co-firing Pulverized Coal and Wood

[redacted]



Biomass Co-firing & Firing

- Multiple European Projects in the past 5 years.
- Up to >70 MWe installation
- Converted from coal to 100% biomass @ full load with ROFA
- NA Feasibility study - 230 MWe unit
  - 100% coal to 100% biomass pellets w/ ROFA
- Co-benefits to reducing CO2
  - Reduction in NOx, SOx, Hg, PM
- Biomass Challenges
  - Address with ROFA & FCT

Wroclaw, Poland
Biomass Co-firing with ROFA

- Impact
  - NOx reduction
  - Combustion improvement
  - Biomass burnout
- Driver – NOx <200 mg/Nm3 by 2016
- ROFA Solution
  - Biomass as energy input – 45%
    - With no reduction in boiler efficiency
  - 63% NOx Reduction from start case
  - LOI <5% (maintain fly ash sales)
  - CO <100 mg/Nm3
  - 36% SO2 Reduction

Vasthamnsverket, Sweden
ROFA & Rotamix

- 240 MWt ~ 70MWe
- Installed in 2005
- ROFA
  - 100% biomass
  - Maintained boiler efficiency
  - NOx & other emissions reduction
- Rotamix
  - Fouling and corrosion risk associated with biomass

Thank You!

Contact Information:

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