REINHOLD ENVIRONMENTAL Ltd.

2016 APC-Wastewater Round Table & Expo Presentation

July 18 & 19, 2016 in Dearborn, MI / Hosted by DTE Energy

WFGD OPTIMIZATION FOR IMPROVED WASTEWATER TREATMENT

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Date: July 19, 2016 – APC and Wastewater Roundtable

CONTENTS:

Solutions to WFGD WW

WFGD Optimization with Sulfite Control

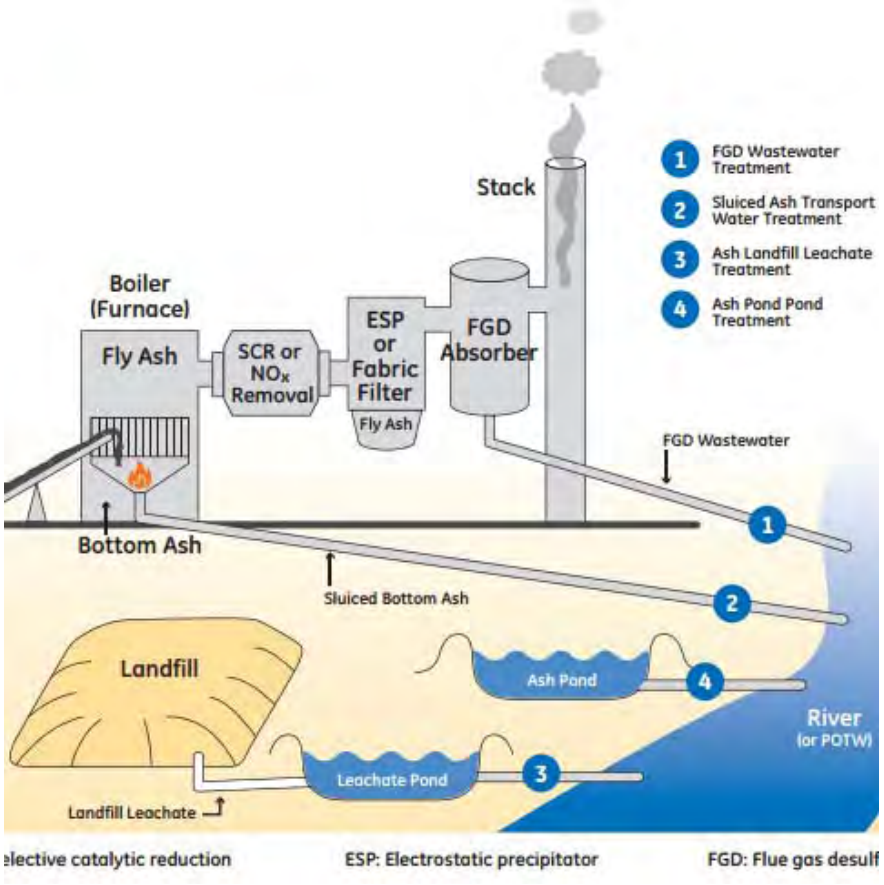
Traditions WWTS

ABMet Biological Treatment

Summary

Solutions to the FGD Wastewater Challenge

Discharges at Coal-Fired Power Plants Impacted by New Regulations



- New challenge to manage the overall water balance of the plant
- FGD wastewater treatment is a significant challenge
- Variability due to type of coal, scrubber, operating regime, additives, load, etc
- Robust solution required

Federal Regulations for FGD Discharges

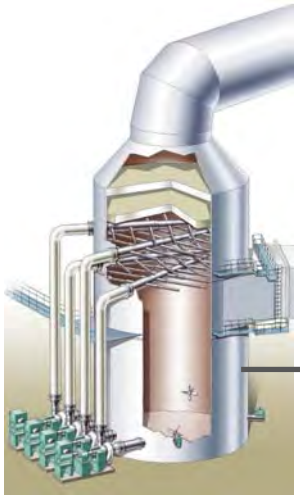
ELG Discharge Limits for FGD Discharges

Constituent	units	30-day avg.	1-day max
Arsenic (total)	µg/L	8	11
Mercury (total)	ng/L	356	788
Selenium (total)	µg/L	12	23
Nitrate + nitrite as N	mg/L	4.4	17

Local Regulators can Require Additional Limits

- Lower limits on arsenic, mercury, selenium and nitrate
- Limits on other constituents, e.g. chlorides, TDS, or boron

Integrated Chemical Precipitation + Biological Treatment Flow Sheet



WFGD absorber with SulfiTrac* sulfite control

Bio-solids Return

Chemical Precipitation Process

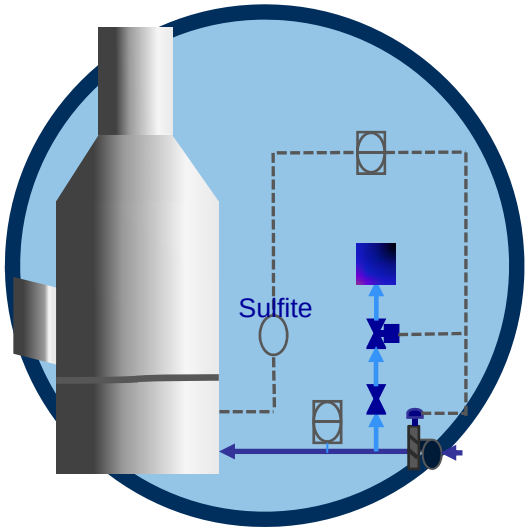
ABMet Biofilters

To Solids Dewatering System

Effluent Discharge

Treat & Discharge Solution – BAT for Existing Sources

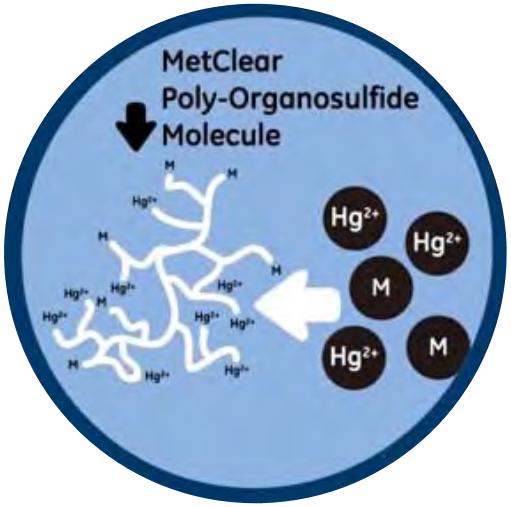
WFGD with Sulfite Control



Reduces dissolved Hg/Se
Se(IV) > Se(VI)

+

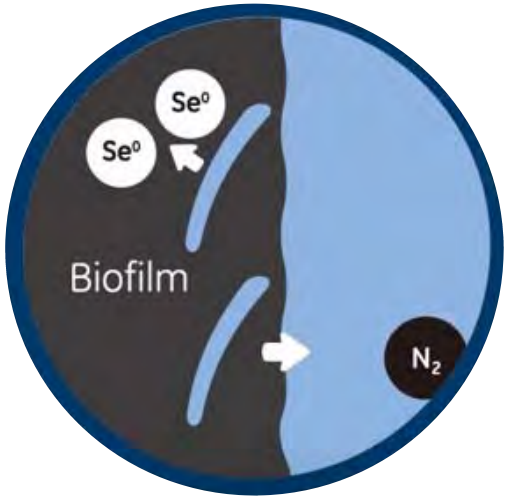
Chemical Precipitation



arsenic
mercury

+

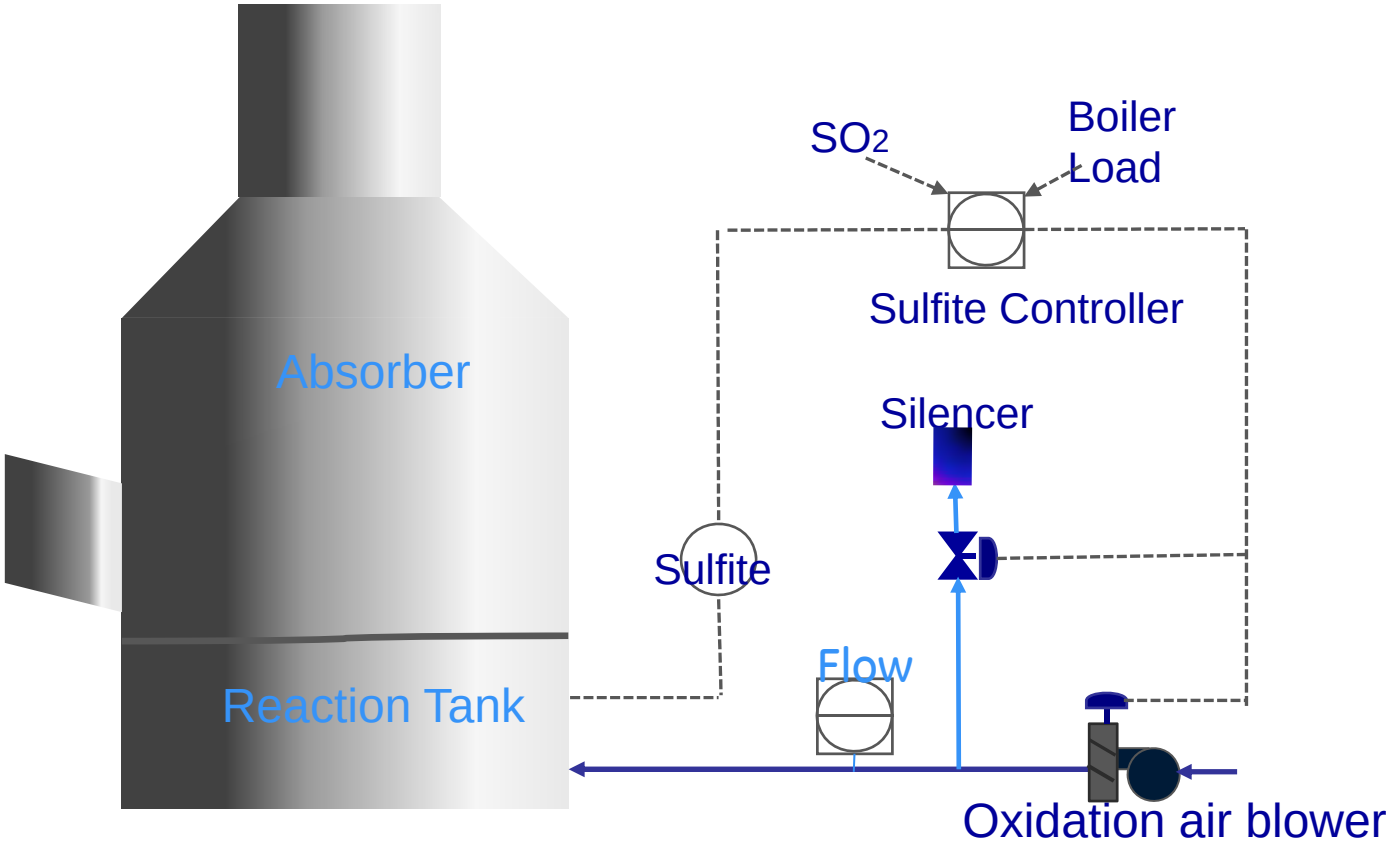
Biological Reduction



selenium
nitrate

WFGD Optimization with Sulfite Control

Efficient Oxidation Air Control with Sulfite Control



Air flow modulated to maintain sulfite set-point

Sulfite Analyzer Installation

- WFGD slurry, 20 to 50 gpm, to analyzer in sample sink
- Calibrated annually using standard analytical method
- Low maintenance

- Recommend weekly to monthly cleaning
- Ring electrode replacement approximately every 1-2 years

GE SulfiTrac* Sulfite Analyzer

Product Specification

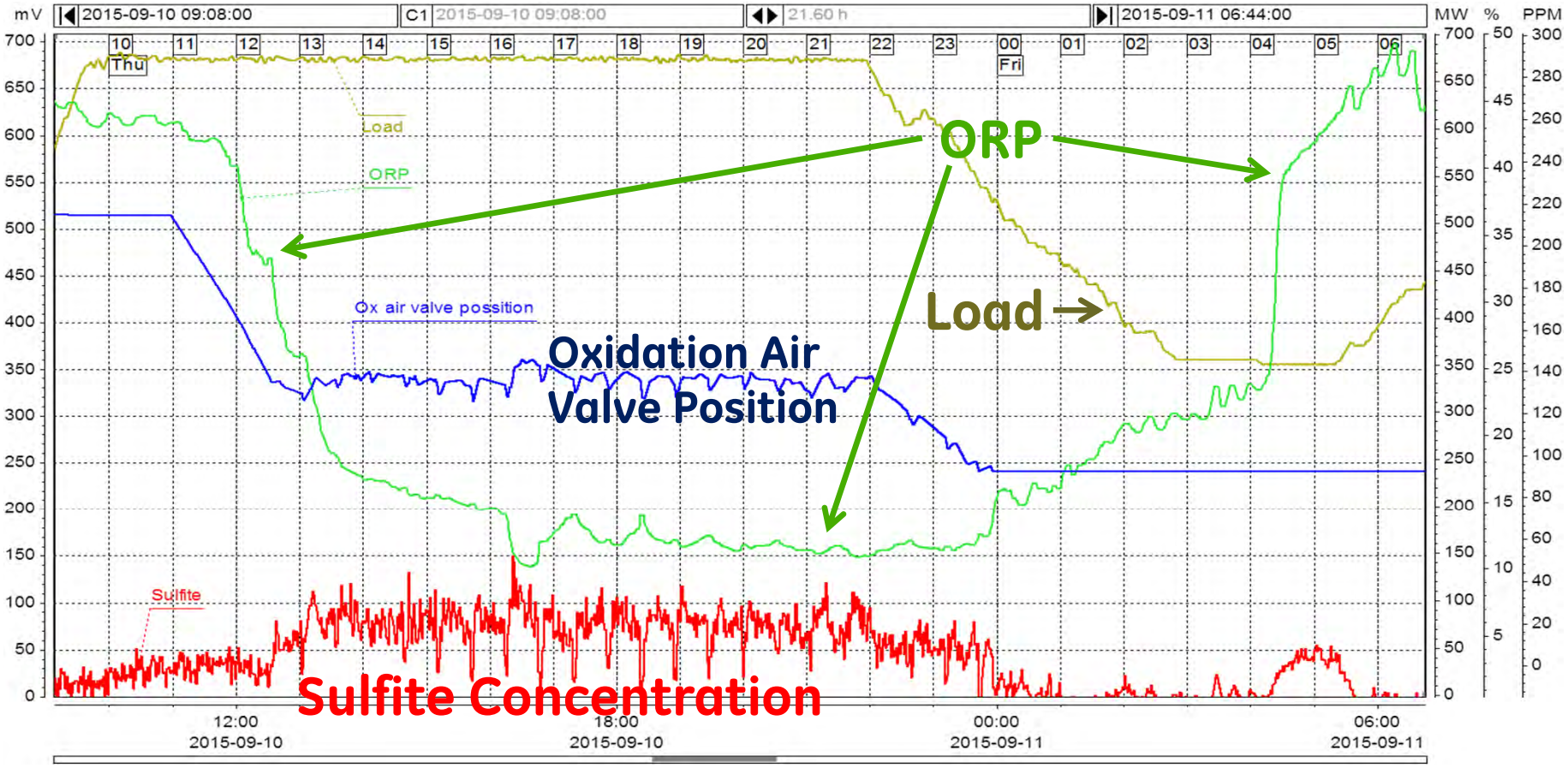
Physical Size	Approximately 12” diameter x 44”H
Weight	50 lbs.
Casing	C-PVC, Stainless steel
Control Box	NEMA 4 rated
Mounting Flange	C-PVC, 150 psig rating
Scraper Assembly	C-PVC/Zirconium/Stainless steel
Probe Surface	Platinum
Operating Temperature	15ºF to 160ºF (-10ºC to +70ºC)
Ambient Temperature	40ºF to 150ºF (5ºC to +65ºC)
Power Supply	24 VDC, ~25 W
Output Signal	4-20 mA, RTD

Robust construction for industrial applications

Recent Sulfite Control Testing and Data

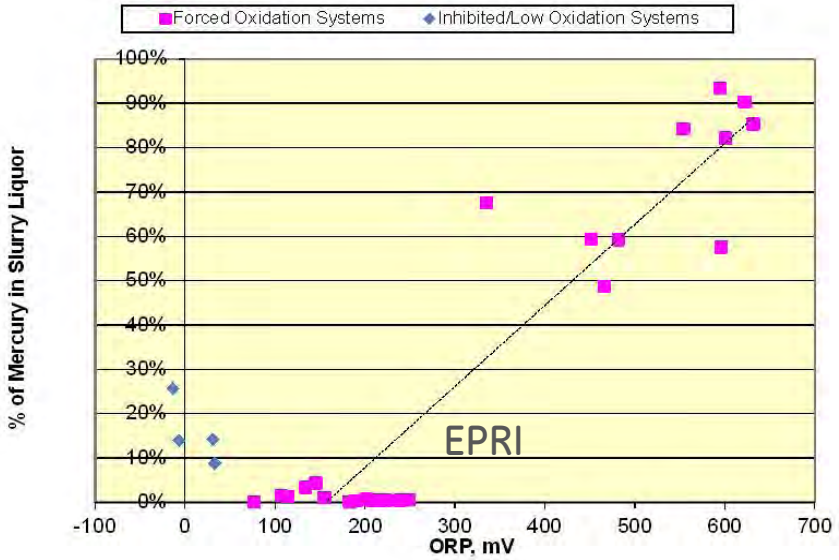
- 2 x 650 MW plant with multiple WFGD absorbers
- 1 of 8 absorbers tested sulfite control
- 7 day test program
  - Baseline (full-oxidation) tested for 2 days
  - Sulfite control at 20 ppm for 4 days
  - Sulfite control with 200 ppm for 1 day
- Sparger system limited air turndown – sulfite control for 12 to 14 hours/day
- Common dewatering system, supernate returned to all absorbers
- Non-ideal testing scenario

Operation with Sulfite Control

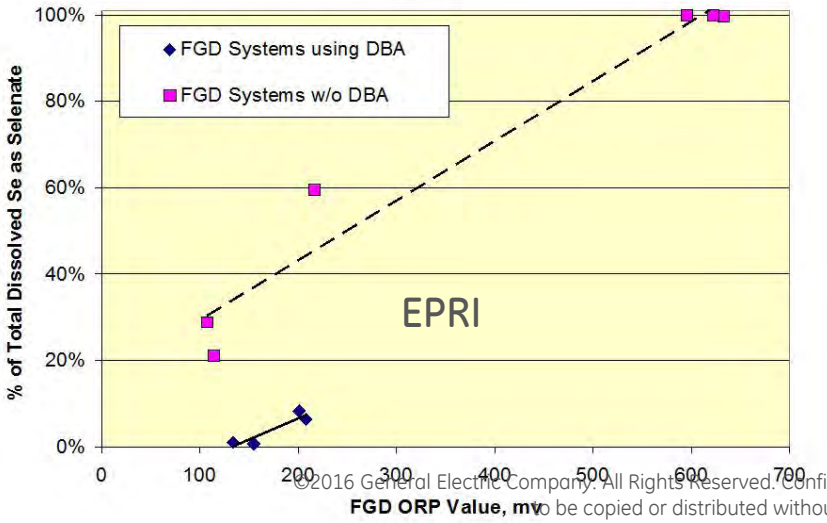


ORP lowered from > 500 mV to < 200 mV

EPRI Results for Mercury and Selenium Speciation Impacts with Change in ORP

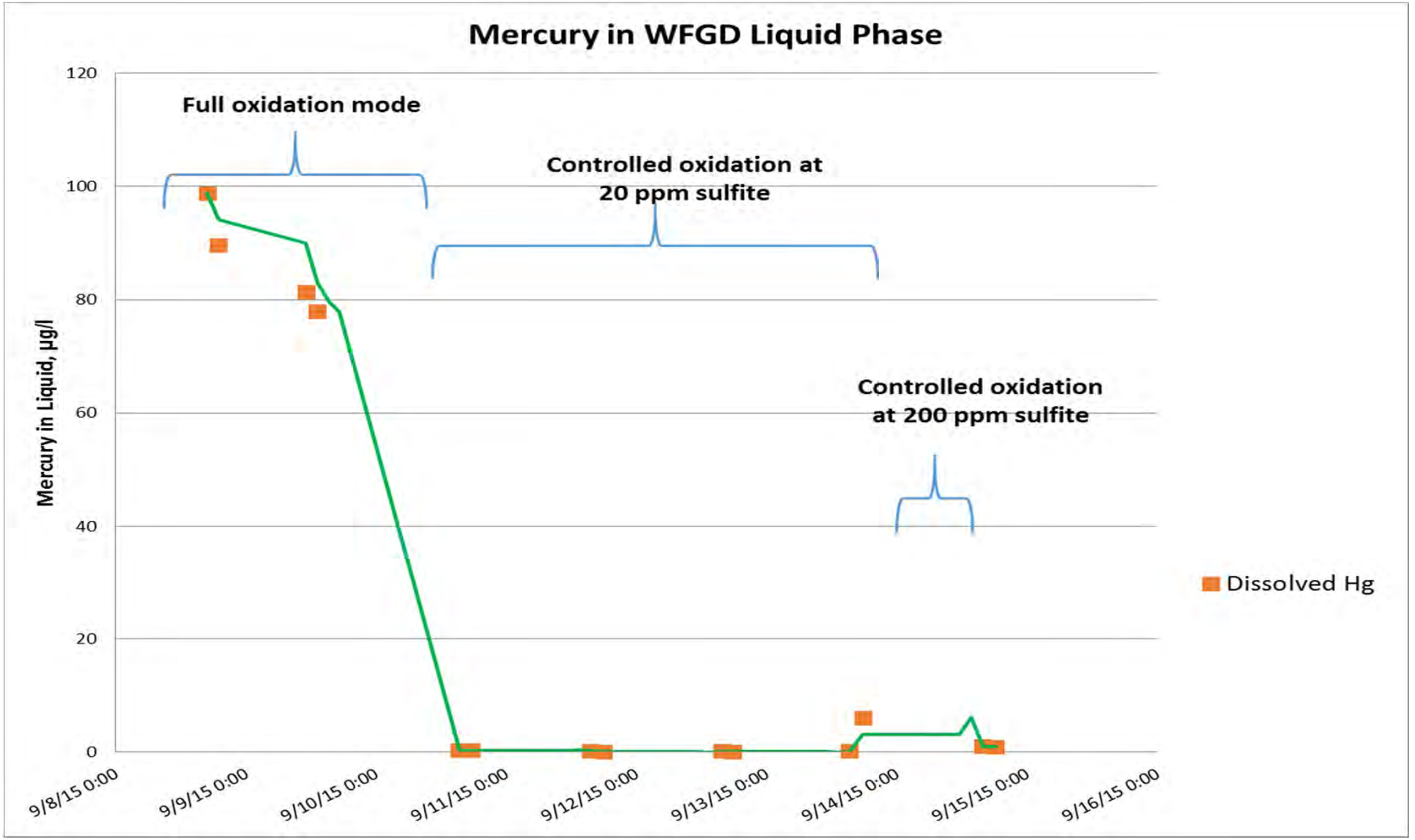


Lower mercury in WFGD liquor with lower ORP

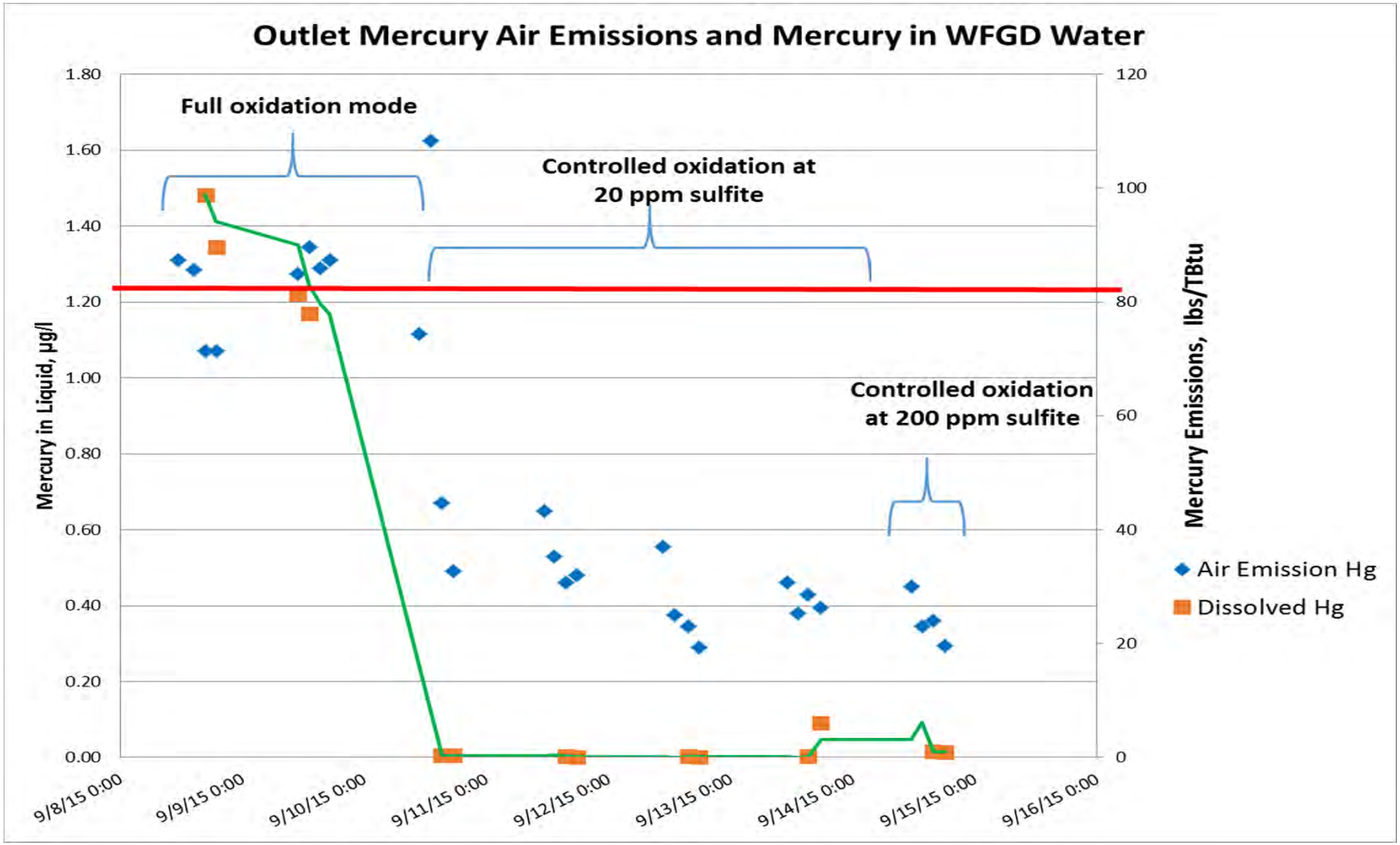


Lower fraction of selenate in WFGD liquor with lower ORP

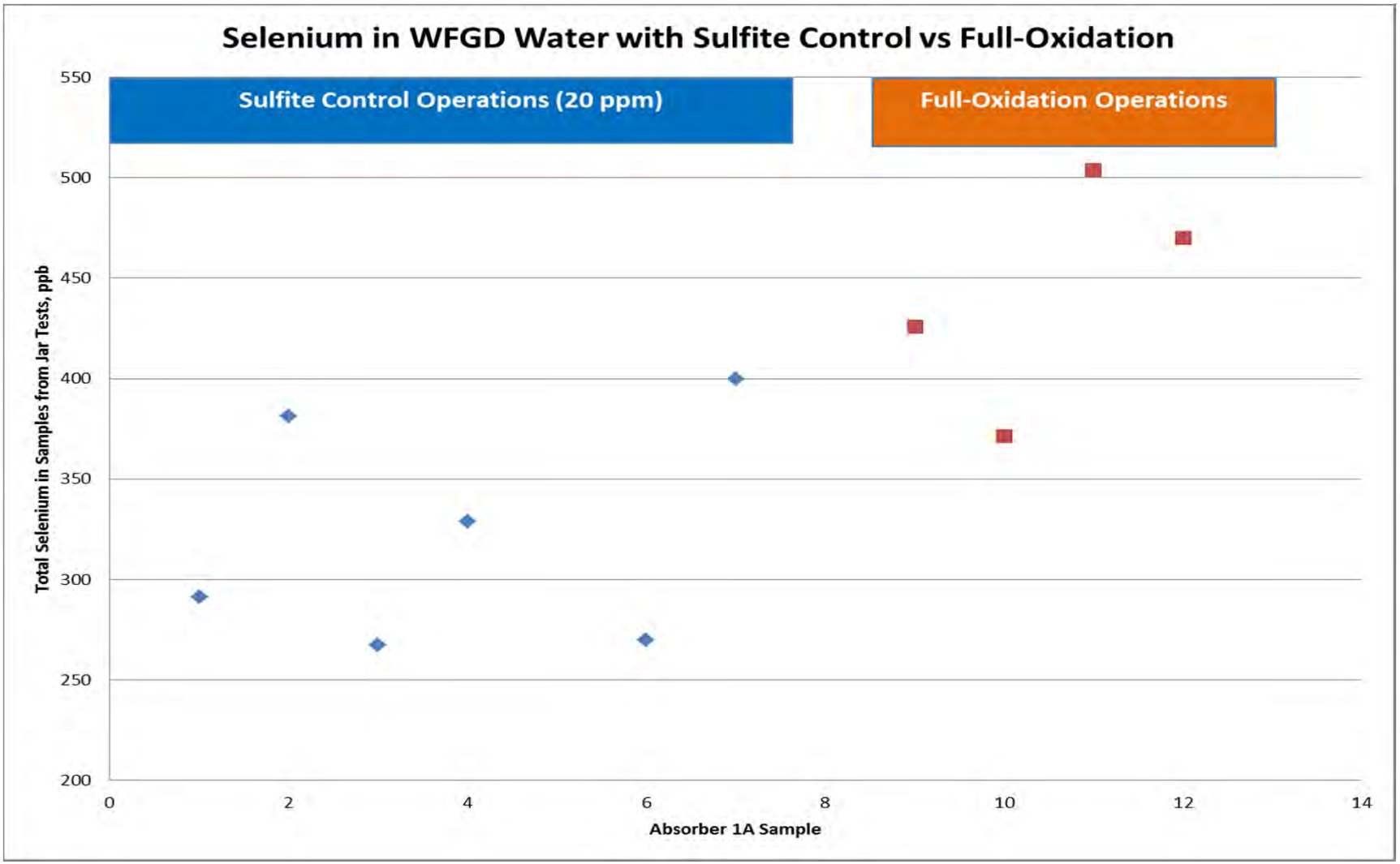
Mercury changes with sulfite control



Mercury changes with sulfite control



Total selenium changes with sulfite control



Benefits of Operation with Sulfite Control

- Reduce variability in scrubber chemistry, lower oxidants in WW
- Hg level in WFGD WW reduced from > 50 µg/l to <1 µg/l
- Total selenium in WFGD WW reduced, selenium speciation shifted away from selenate
- Reduce mercury air emissions, >80% reduction in re-emissions
- OpEx$ savings, lower power consumption
- Operate with confidence in sulfite concentration to prevent sulfite blinding and maintain gypsum quality
- Reduce manganese precipitation that contributes to scale formation and corrosion potential

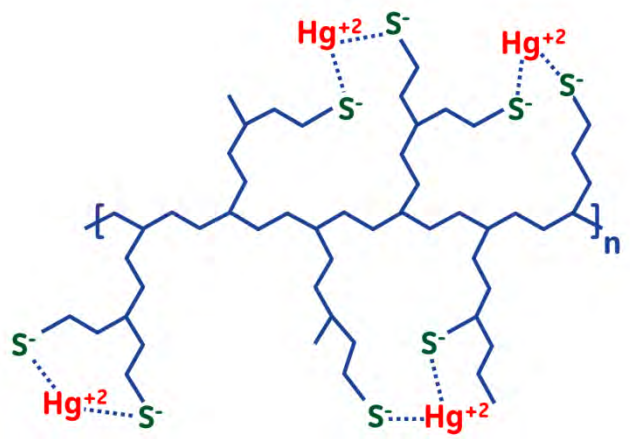
WFGD sulfite control optimizes WFGD purge for improved treatment in WWTS

Treat & Discharge

Physical-chemical (P/C) Treatment

Chemical products for P/C

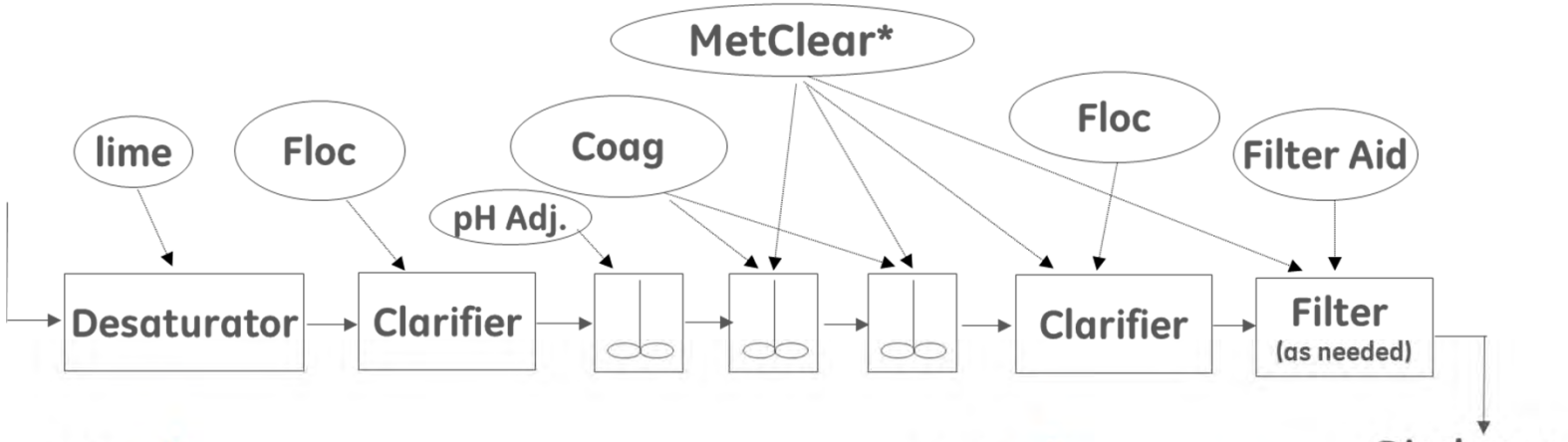
Objective: precipitation of metals & separation of TSS

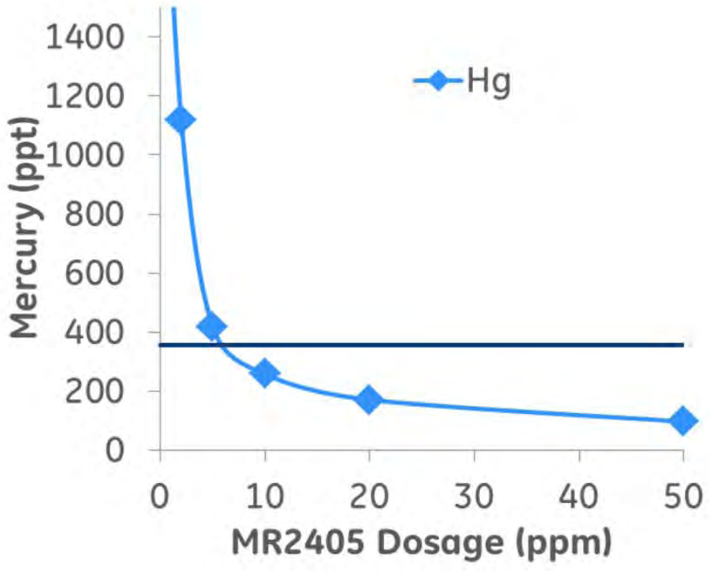


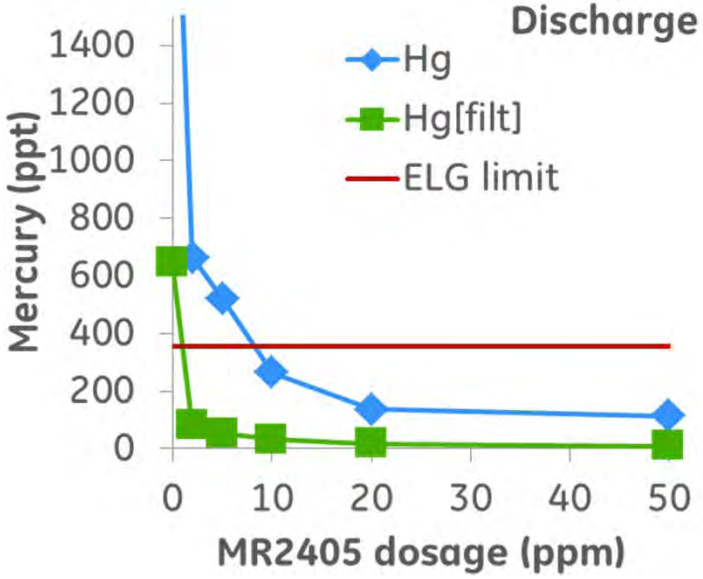
- MetClear*
  - ➢ selective Hg removal chemistry
  - ➢ effective for Se precipitation
- PolyFloc* & Novus* – anionic and cationic flocculants
- KlarAid* – complete line of coagulants

Reducing agents & organic molecules susceptible to oxidation

Hg removal with P/C treatment







Se removal with P/C treatment

Example: northeast coal-fired power plant

- 650 MW unit, Eastern bituminous w/ high Se, LSFO wFGD

Selenium Issue

- Highly variable (2-20 ppm) dissolved Se in purge water
- Challenged to meet environmental permit
- Limited previous success w/ ferric or ferrous chemical treatments
- New chemical program implemented to remove Se

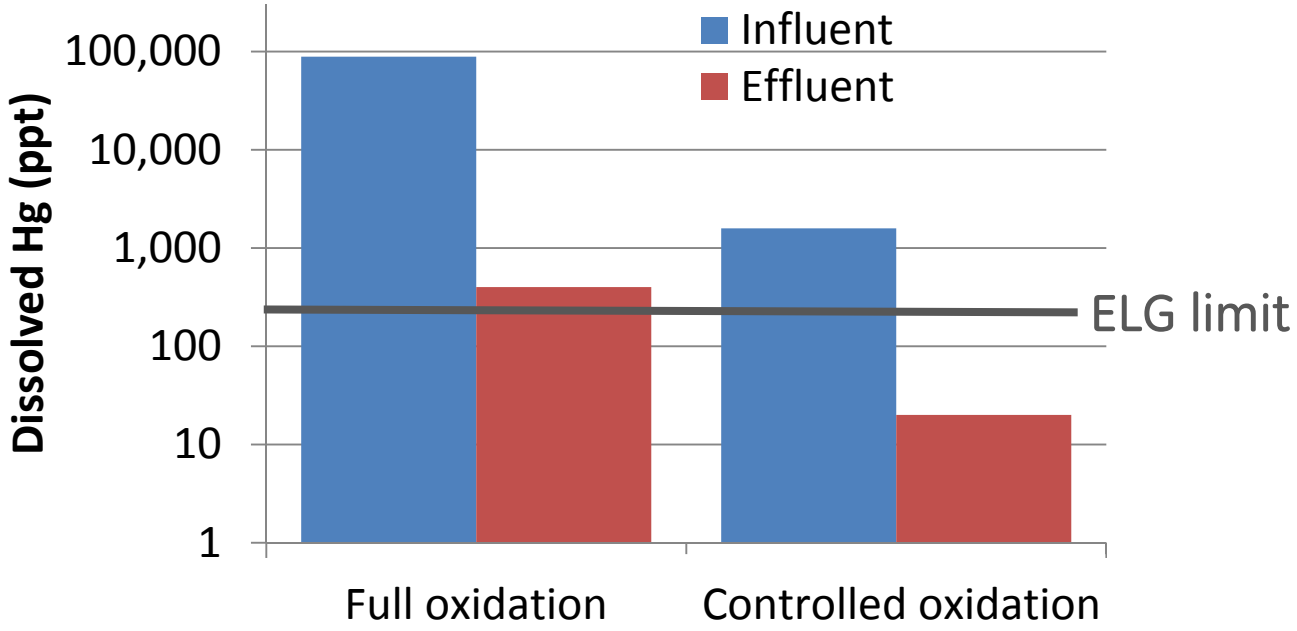
Se speciation:

Selenite	Selenate	SeCN	MeSe (IV)	Unknown Se Species
73%	3%	5%	1%	18%

Se removal:

Selenite	Selenate	SeCN	MeSe (IV)	Unknown Se Species
88 - 92%	50 -70%	60%	0%	85% - 98%

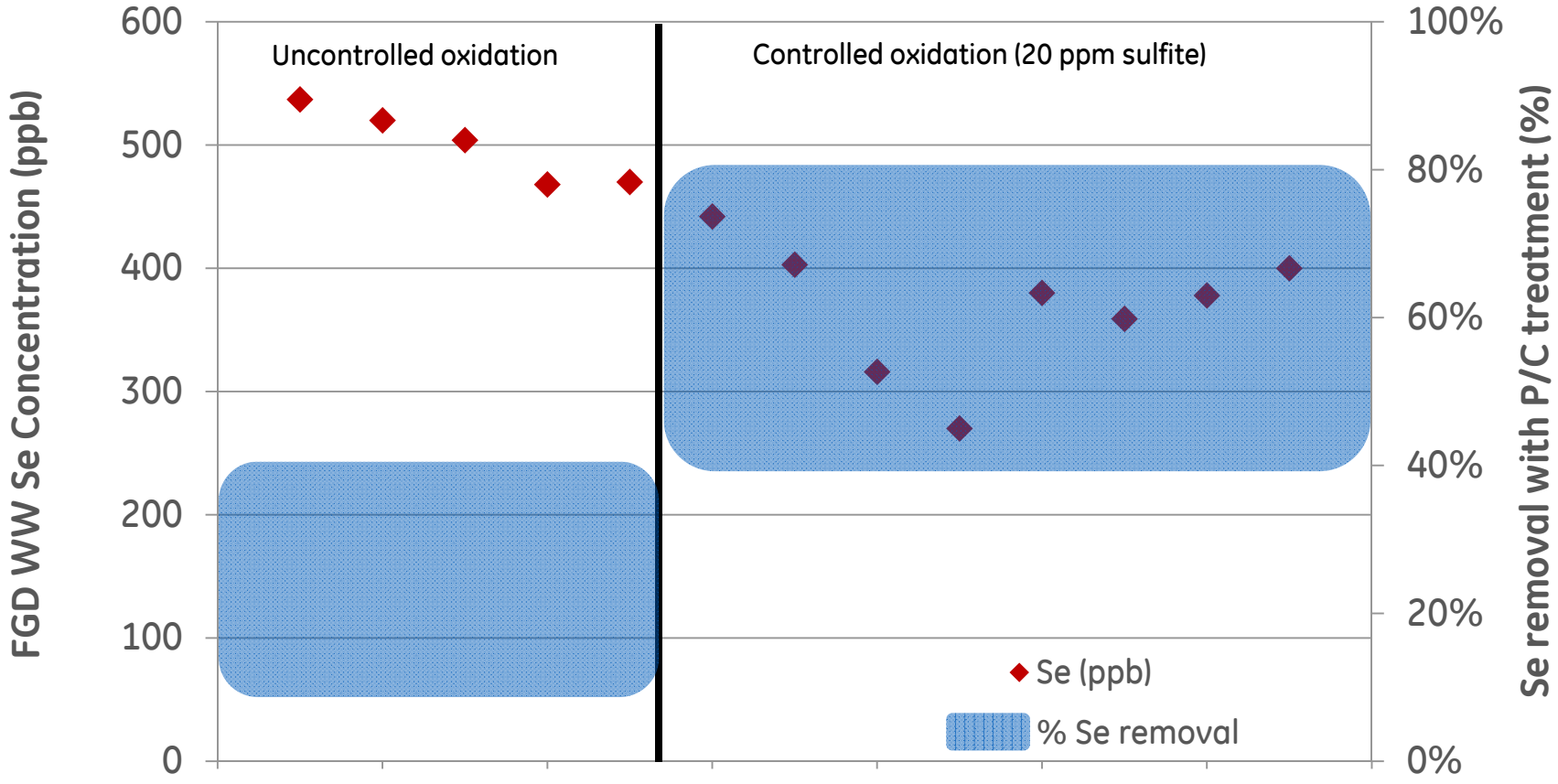
Sulfite control benefits to P/C Hg removal



WFGD w/ sulfite control:

- Significant reduction of WWTP influent Hg
- Reduced variability
- Reduced oxidant loading

Improved P/C Se removal with sulfite control



Influent Se concentration reduced while P/C removal more effective

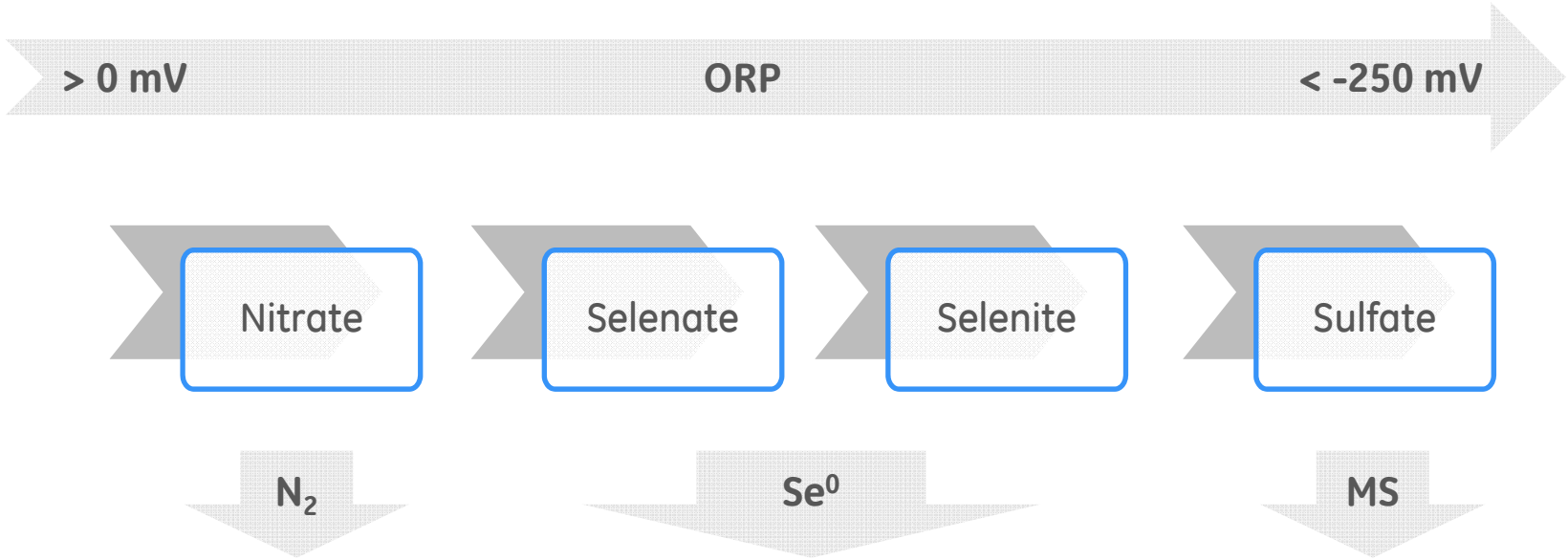
Benefits to P/C treatment with sulfite control

- Reduced Hg and Se influent concentrations
- Se: complete oxidation to selenate avoided
  - ➢ P/C removal more effective
- Reduced oxidizing species entering WWTP
  - ➢ P/C chemicals not consumed/oxidized
- Reduced variability
  - ➢ Jar testing more representative

Treat & Discharge

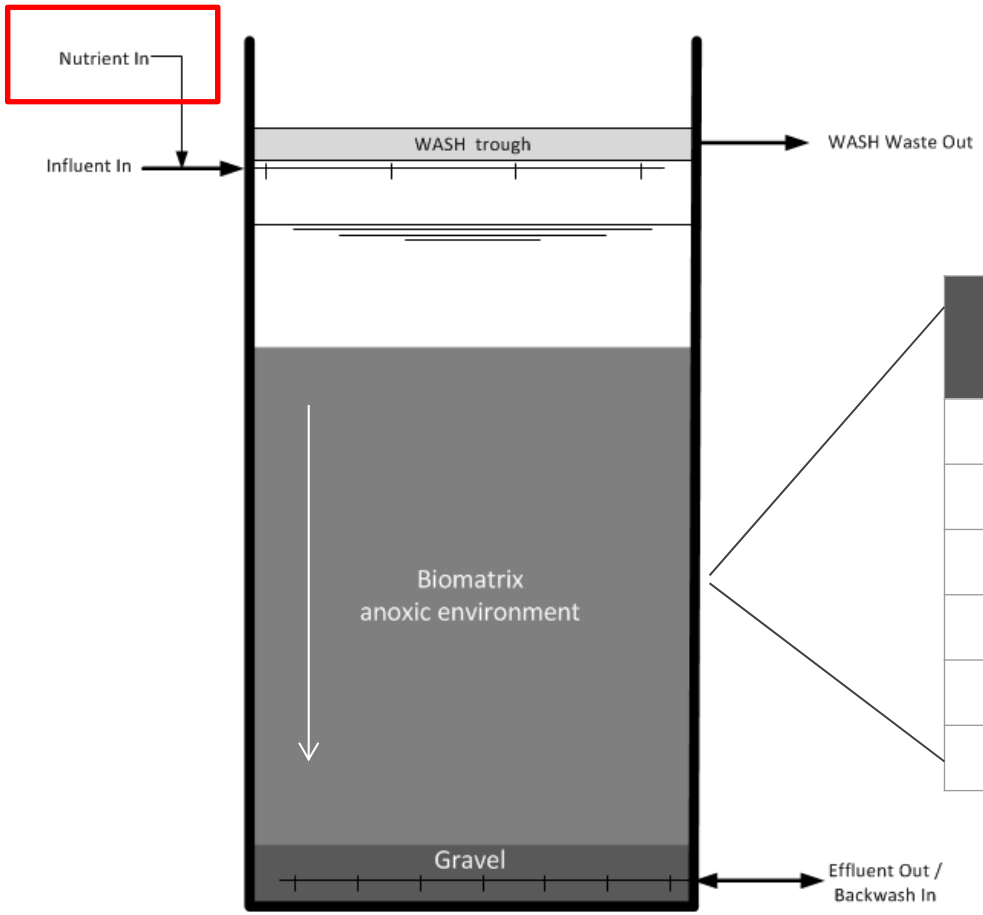
ABMet* Biological Treatment

Biological Reduction of Key Constituents in FGD Wastewaters



Single-Step Process Without Post-Treatment Required

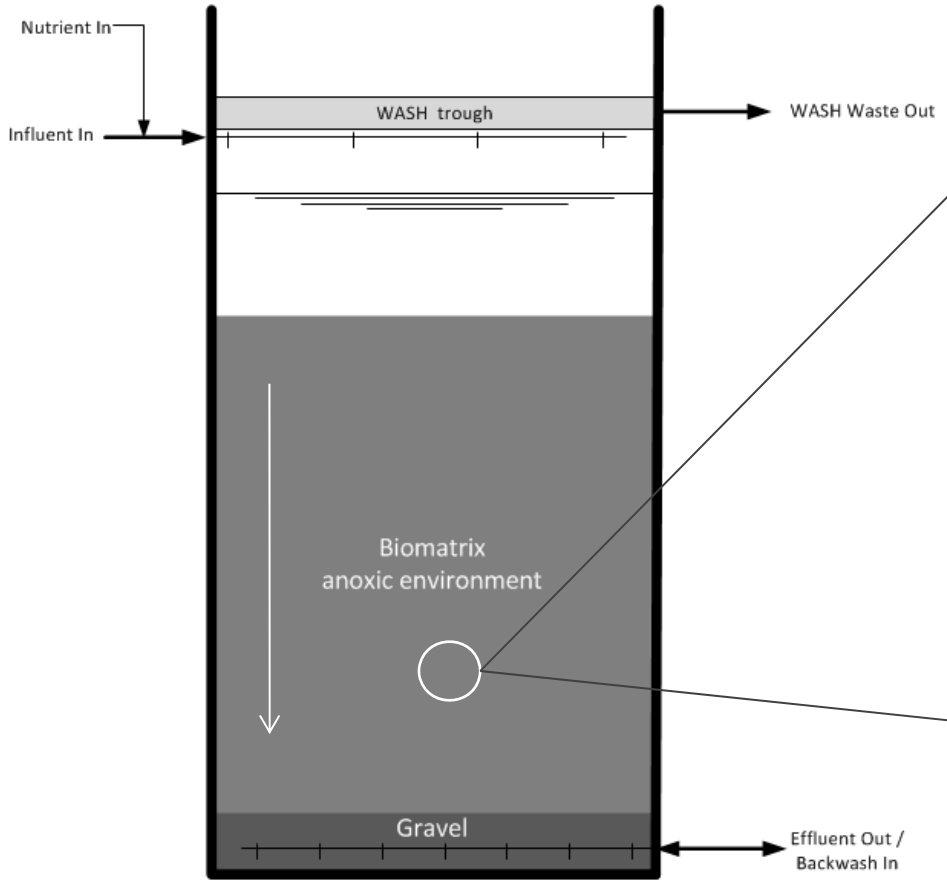
Control of Conditions within Biofilter to Optimize Selenium Removal

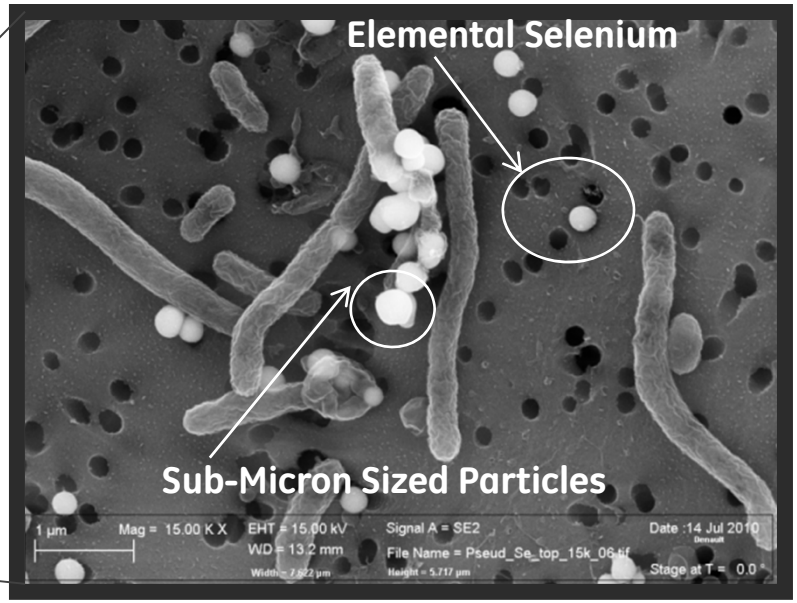


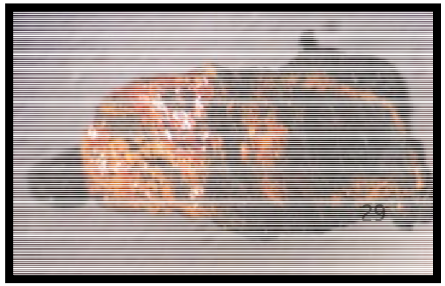
Maintaining a stable, moderate influent ORP reduces the gap to hitting "sweet spot" ORP for nitrate and selenium removal = smaller reactor volume

Electron Acceptor	Approximate ORP
Oxygen	>0 mV
Nitrate	< 0 mV
Nitrite	< -50 mV
Selenate	< -100 mV
Selenite	< -150 mV
Sulfate	< -200 mV

Biofilter Design Retains By-Products to Product and Effluent Ready for Discharge







Integrated Chemical Precipitation + Biological Treatment Flow Sheet

WFGD Absorber
~~with SulfiTrac* control~~

Without sulfite control, reducing agents such as sodium (bi)sulfite have been incorporated into the phys-chem train

Bio-solids Return

Chemical Precipitation Process

To Solids Dewatering System

ABMet Biofilters

Effluent Discharge

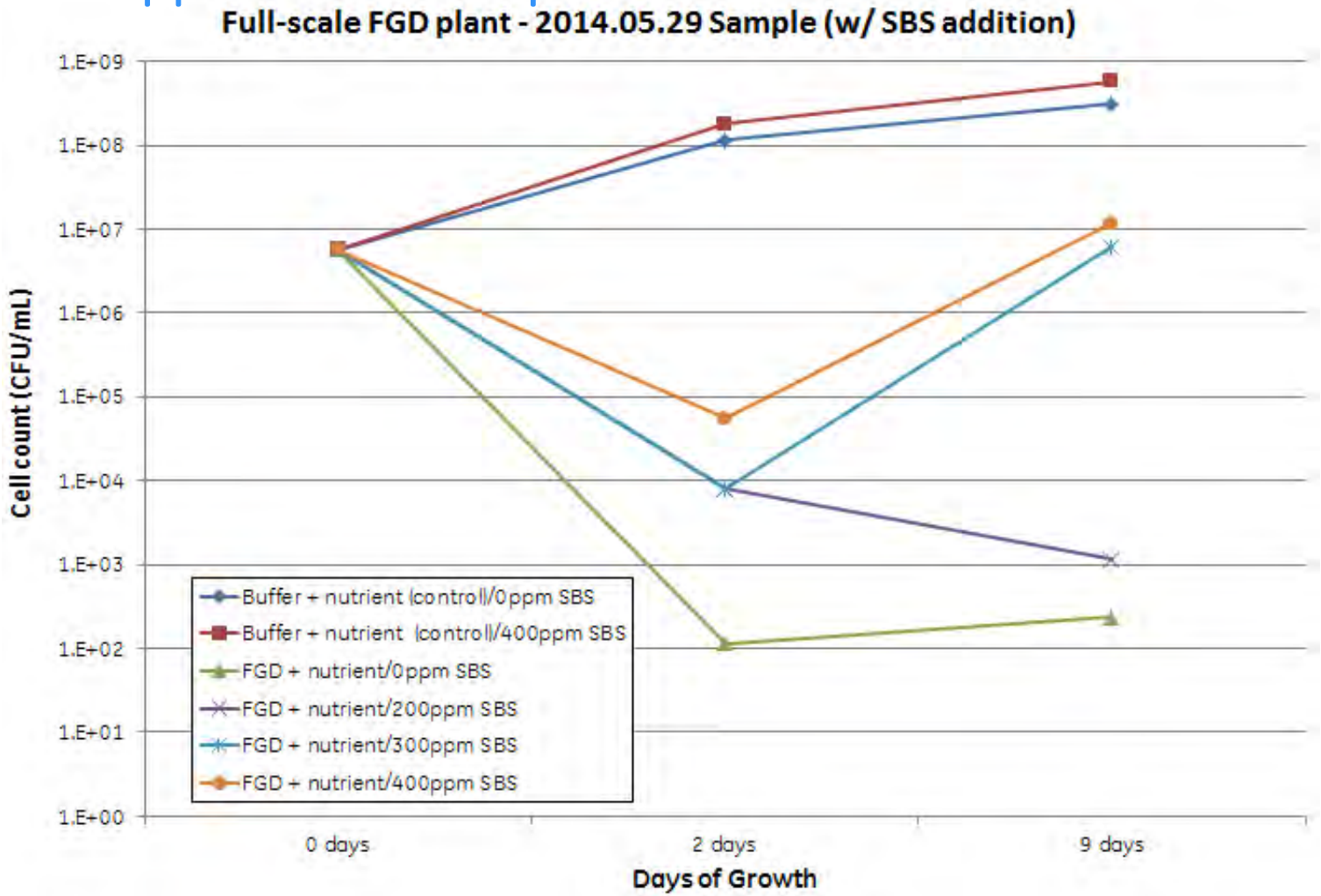
Oxidant generation in the scrubber

In addition, dithionate (S … be formed in the scrubber by adding excess oxidati … ot easily treatable. $S_2O_8^{2-}$ would degrade ad … th compounds would be required to be treated or … Japan.

Unlike some measuremen … pecific chemical species. It is a measurement bas … whole. As such, many oxidizers could increase s … cid are thought to be the main oxidizers within the … ought into contact with a solution, it may react to … uced by a corresponding amount in the process. F … t with scrubber slurry, it may react with slurry con … y, in turn, react with the slurry to form hypochloro …

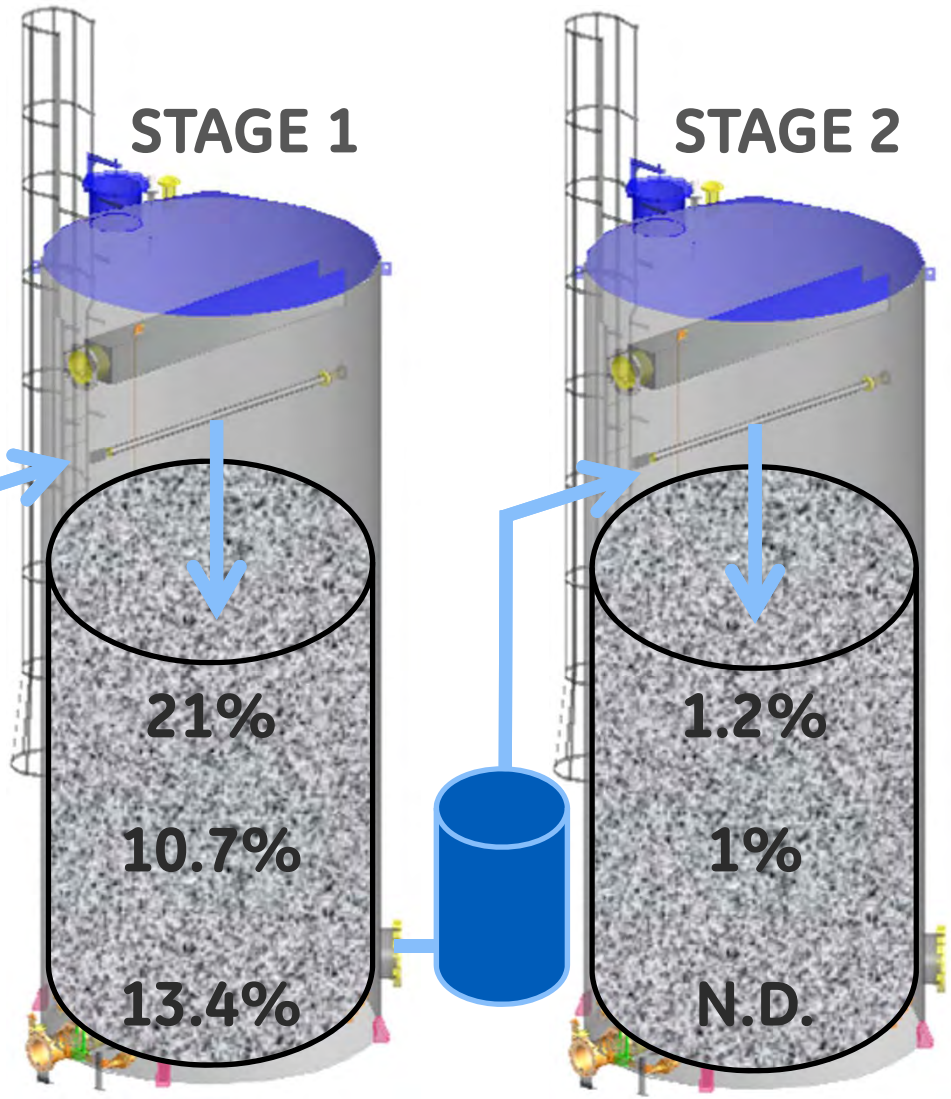
Impact of oxidants & reducing agents

Sodium Bisulfite (SBS) Addition + Cell Growth (plant in USA, total oxidant of 25ppm chlorine-equivalent)



“Nuisance” bacteria can persist in high-ORP feed

Influent ORP was often 250-600mV



Arcobacter = capable of producing excessive biofilm, resilient to oxidants

Routinely present in Stage 1 reactor exposed to high ORP feed, nearly absent in Stage 2 with lower ORP feed

Summary

WFGD Optimization for Improved WW Treatment

Reduced variability

- Actively controlled oxidation negates ORP swings observed in WFGD operation

Reduced oxidizing species in WW stream

- Protects both WWT chemicals & biological system
- Removes requirement to add reducing agent for optimum WWT
- Maintains desired bacteria for nitrate/selenium removal

Decreased dissolved contaminant loading on WWTP

- Significant reduction in WW Hg concentration
- Reduction in WW Se concentration
- Avoid complete oxidation of Se to selenate form

WFGD sulfite control optimizes WFGD purge for improved treatment in WWTS