CONTINUOUS WATER QUALITY SENSING FOR FLUE GAS DESULFURIZATION WASTEWATER

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Director of UAB EITD
Project Team - Overview

**Prime**
Multidisciplinary Team of University Professors, Staff Members, and Students

**Subawardee**
University Affiliated Research Institution

**In-Kind Cost Share**
Industry Partner
Project Team – Expertise

UAB EITD

Complex System Design and Integration for Extreme Environments

• Consistently delivered on well over $60M of NASA contracts over past 8-10 years
  ○ Sole Supplier of Powered Cold Stowage Units for NASA ISS transport operations
    ○ POLAR (+4C to -95C)
    ○ GLACIER (+4C to -160C)
    ○ MERLIN (+48.5C to -20C)
Project Team – Expertise

UAB EITD

- Diverse Array of Services Offered
  - Rapid Prototyping
  - Electrical, Mechanical, Software, & System Engineering

- AS9100, ISO9001 Certification
  - 4,500 ft² of Production Labs
  - 13 ESD workstations
  - NASA electronics process standards
    - Soldering (J-STD-001ES)
    - Assembly (NASA-STD-8739.1)
    - Harness (NASA-STD-8739.4)

Biosensor for anthrax detection
Project Team – Expertise

Metrohm

A Leading Manufacturer of High Precision Instruments for Chemical Analysis

• Swiss based parent company

• Extensive Application Knowledgebase
  o Application Notes
  o Highly Educated & Experienced Support Staff

• Electrochemistry Instruments
  o Benchtop 884 VA Voltammetry Unit
  o On-Line ADI2045 VA Process Analyzer
Unique Resources

Water Research Center (WRC)

- Opened in 2012 by Georgia Power & Electric Power Research Institute (EPRI)
  - Operated by Southern Research

- Located on-site at Georgia Power’s Plant Bowen
  - 9th Largest U.S. Power Plant in Net Generation (3.38 MW)

- 7 Focus Areas to include:
  - Low Volume Wastewater Treatment
  - Moisture Recovery
  - Zero Liquid Discharge
  - Water Modeling, Monitoring, & Best Management Practices
Problem Statement - **Overview**

Key waste streams from updated USEPA guidelines.

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## Problem Statement – *EPA Requirements*

Steam Electric Power Generation Effluent Guidelines for Coal-fired Power Plant Wastewater

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>Parameter</th>
<th>Daily Maximum</th>
<th>30-Day Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FGD Wastewater for Discharge</strong></td>
<td>As (μg/L)</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Se (μg/L)</td>
<td>23</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Hg (ng/L)</td>
<td>788</td>
<td>356</td>
</tr>
<tr>
<td></td>
<td>NO₃/NO₂ as N (mg/L)</td>
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<td>4.4</td>
</tr>
<tr>
<td><strong>FGD Wastewater under Voluntary Incentive</strong></td>
<td>As (μg/L)</td>
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<td>24</td>
</tr>
<tr>
<td></td>
<td>Se (μg/L)</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Hg (ng/L)</td>
<td>39</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>TDS (mg/L)</td>
<td>50</td>
<td>24</td>
</tr>
</tbody>
</table>

Problem Statement

Measuring Selenium Concentrations

Possible formations of Selenium in FGD Wastewater

- **Selenate**
  - $p\ M^{2+} + q\ H^+ + r\ \text{SeO}_4^{2-} \rightleftharpoons [M_pH_q(\text{SeO}_4)_r]^{(2p+q-2r)+}$

- **Selenite**
  - $p\ M^{2+} + q\ H^+ + r\ \text{SeO}_3^{2-} \rightleftharpoons [M_pH_q(\text{SeO}_3)_r]^{(2p+q-2r)+}$

Where:
- $M = \text{Mg, Ca, Sr, Mn, Cu, Zn, Cd}$, etc.
- $H$ = Protonation of selenium species

Torres et al., “Selenium Chemical Speciation in Natural Waters.”
Proposed Solution

Novel Sample Preparation Methodology

- Sample Prep to facilitate detection with COTS devices

- Methodology details are considered proprietary

- 3 Stages
  - UV-Peroxide Digester
  - Matrix Manipulation (removal & polishing)
  - Reduction
Proposed Solution

Concentration Measurements

884 VA Voltammetry Unit

- Low Limit of Detection:
  - Se: 300ppt
  - As, Hg: 100ppt

- Replaceable Measuring Head:
  - Multi-Mode Electrode Pro
    - Hanging Mercury Drop (Se)
  - scTRACE Gold Electrode
    - Solid State (As, Hg)

- Relatively portable, with low maintenance and operating costs (vs. ICP-MS)
Significance of Results

• Enable closed loop control of contaminant concentrations in effluent discharge

• Provide superior data for 30-day averaging compliance
  o Easier to prove compliance
  o Better for the environment

• Significantly reduce operating costs of coal fired power plants with wet FGD systems
  o Replace periodic grab sample analysis by off-site laboratories
  o Minimize required FGD wastewater treatment reagents and equipment
Relevance to Fossil Energy

• No longer blindly discharging contaminants into the environment!

• Global Impact
  • ~1/3rd of US Coal Fired Power Plants have wet FGD systems
  • By comparison, China exceeds this number by 3-5 times

• Adoption of continuous monitoring has many attractive benefits
Statement of Project Objectives

Key Features

Continuous Water Quality Monitor for FGD Wastewater

- Concentrations of Trace Metals
  - 1st Priority: Se
  - 2nd Priority: As, Hg

- Reliable, Automated In-Field Operation
  - Goal for Prototype: 1 week of intervention-free operation

- High Measurement Frequency (<1hr latency)
Statement of Project Objectives

Multi-Phase Approach

I. Development of Batch Process for Sample Preparation

II. Design and Development of Continuous Sample Preparation Prototype

III. Demonstration Unit Integration and Field Testing
Project Milestones & Schedule

• Period of Performance: 18 mths (Aug ’16 – Jan ‘18)
  - ≈ 6mths / Phase

• Milestone Distribution Basis (10 total):
  - Validation of Critical Sample Preparation Steps including:
    - UV-Peroxide Digester
    - Matrix Manipulation (removal & polishing)
    - Reduction
  - Validation of Critical “” Steps throughout:
    - Batch Process Development
    - Continuous Prototype Development
    - Demonstration Unit Integration
Budget

Total Budget: $439,986

- Labor: 24.4%

- Equipment & Supplies: 12.7%

- Contractual: 44.2%
  - In-Kind Cost Share from Metrohm: 9%
  - Sub-Award to Southern Research: 35.2%
    - Labor: 40.3% (of sub-award)
    - Supplies: 2.7% (of sub-award)

- Indirect: 17.1%
Risk Management
(Probability, Impact)

• Technical Risk: (Moderate, High) Failure of primary sample preparation methodology to produce desired results.
  • Mitigation: Two contingency methodologies identified before proposal submission.

• Organizational Risk: (Moderate, Moderate) Labor overruns due to difficulty in identifying sample preparation process.
  • Mitigation: Minimize labor costs by leveraging team expertise:
    o UAB to leverage Metrohm expertise in hardware design
    o SR WRC to leverage in-house experience evaluating other attempts to monitor and treat FGD wastewater
Project Status

• Phase I development is underway
  o UV-Peroxide Digester design ongoing
    ⬤ Custom design to allow for re-use of key components for continuous prototype.
  o UV-Peroxide Digester Procedure Document Complete

• Less than 1mth behind schedule
  o Slow award acceptance and sub-award distribution timeline
    ⬤ Work around: At-risk accounts at UAB & SR
  o Personnel time conflicts
    ⬤ Mitigation: Completion of other projects imminent
  o UV-Peroxide Digester Component Re-usability requirement
    ⬤ Awaiting Metrohm Design Input based on Process Analyzer design
Questions?