Wet Flue Gas Desulfurization Upgrades for MATS Regulatory Compliance

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www.met.net
MET Historical Milestones

**Buell Engineering Company**: Mechanical collectors, ESP & fabric filter product lines

1934

Envirotech’s Buell & Chemico FGD Divisions acquired by General Electric and incorporated as General Electric Environmental Services Inc (GEESI)

1971

MET becomes stand alone corporation with the sale of parent Marsulex, Inc.

1981

Envirotech acquired Buell

1997

Marsulex, Inc. acquired GEESI and renamed Marsulex Environmental Technologies

2011

MET is a full service emission control company with addition of ESP & fabric filter product lines

2012

A LONG AND SUCCESSFUL TRACK RECORD DATING BACK TO THE BEGINNINGS OF AIR EMISSION CONTROL SYSTEMS
| Country      | MW     | | Country      | MW     |
|--------------|--------| | Country      | MW     |
| Germany      | 8,240  | | Canada       | 315    |
| United States| 18,381 | | France       | 1,800  |
| Japan        | 5,925  | | Korea        | 4,250  |
| Netherlands  | 2,585  | | China        | 40,365+|
| United Kingdom| 2,000  | | Taiwan       | 1,000  |
| Finland      | 1,000  | | Viet Nam     | 1,200  |
| Poland       | 1,740  | | Israel       | 2,250  |
| Austria      | 1,180  | | Brazil       | 135    |
| Slovenia     | 275    | | Slovakia     | 220    |
| Saudi Arabia | 160    | | Czech Republic| 1,570 |
| Croatia      | 210    | | Italy        | 960    |

Note: The table shows the capacity of Wet Flue Gas Desulfurization installations worldwide. The figures represent the maximum MW capacity of these installations as of the latest available data.
Utility Mercury and Air Toxic Standard (MATS)

The rule sets numeric emission limits for filterable Particulate Matter (PM), Hydrogen Chloride (HCl) and Mercury (Hg) for new and existing power plants.

- The standard for organic air toxics is a work practice standard
- In some cases, the standards are “surrogates” for a number of pollutants. (e.g. setting a HCl emissions limit to control all acid gases)
- Sources can choose to meet the primary standard or an alternate standard. (e.g. MATS also sets a numeric SO2 emissions limit as an alternate surrogate for acid gases)

MATS covers approx. 1,100 coal and 300 oil fueled boilers >25 MW

Compliance required by April 2015, with an option of 1 yr extension on a case-by-case basis. Delay is expected.

Source: EPA’s MATS Regulatory Impact Analysis
## MATS Emissions Limits for Coal & Oil Fired

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Filterable Particulate Matter</th>
<th>Hydrogen Chloride**</th>
<th>Mercury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Unit designed for not low rank virgin coal</td>
<td>0.030 lb/MMBtu (0.30 lb/MWh)</td>
<td>0.00200 lb/MMBtu</td>
<td>1.2 lb/TBtu (0.020 lb/GWh)</td>
</tr>
<tr>
<td>Existing Unit designed for low rank virgin coal</td>
<td>0.030 lb/MMBtu (0.30 lb/MWh)</td>
<td>0.00200 lb/MMBtu</td>
<td>4.0 lb/TBtu (0.040 lb/GWh)</td>
</tr>
<tr>
<td>Existing - IGCC</td>
<td>0.040 lb/MMBtu (0.40 lb/MWh)</td>
<td>0.00050 lb/MMBtu</td>
<td>2.5 lb/TBtu (0.030 lb/GWh)</td>
</tr>
<tr>
<td>Existing – Solid oil-derived</td>
<td>0.0080 lb/MMBtu (0.090 lb/MWh)</td>
<td>0.00050 lb/MMBtu</td>
<td>0.20 lb/TBtu (0.0020 lb/GWh)</td>
</tr>
<tr>
<td>New unit designed for not low rank virgin coal</td>
<td>0.0070 lb/MWh</td>
<td>0.00040 lb/MWh</td>
<td>0.00020 lb/GWh</td>
</tr>
<tr>
<td>New unit designed for coal low rank virgin coal</td>
<td>0.0070 lb/MWh</td>
<td>0.00040 lb/MWh</td>
<td>0.040 lb/GWh</td>
</tr>
<tr>
<td>New – IGCC</td>
<td>0.070 lb/MWh^b 0.090 lb/MWh^c</td>
<td>0.00200 lb/MWh^d</td>
<td>0.0030 lb/GWh^e</td>
</tr>
<tr>
<td>New – Solid oil-derived</td>
<td>0.020 lb/MWh</td>
<td>0.00040 lb/MWh</td>
<td>0.0020 lb/GWh</td>
</tr>
</tbody>
</table>

**The SO2 emissions alternative for existing coal-fired sources is 0.02 lb/MMBtu (1.5 lb/MWh)**
Typical Limestone Process Flow Diagram

Operations and Design

- Flue Gas Inlet
- Purge
- Belt Filter
- Limestone Slurry Tank
- Oxidation Air
- Ball Mill
- Limestone
- Silo
- To Stack
**Typical WFGD Processes**

**Operations and Performance Improvements**

**Operational Issues**
- Poor gas distribution
- Low spray coverage
- Wall sneakage
- Low ME efficiency

**Expected Improved Performance**
- SO₂ Removal upwards of 99%
- Upgraded WFGD can remove up to 70% of particulate matter
- Upgraded WFGD will control HCl at same or higher efficiency than SO₂
WFGD Terminology

Liquid-to-Gas Ratio

- L/G is the ratio of recycle slurry to absorber outlet gas flow
- The amount of surface system available for reaction with SO$_2$ is determined by L/G
- L/G ratio can be changed by altering either recycle flow rate or flue gas flow rate
- Liquid flow is typically varied by changing the number of operating recycle pumps
WFGD for MATS Compliance

Improve Scrubber Performance

- CFD Modeling
- Absorber Recycle Sprays
- Modify Open Spray Towers
- Recycle Pumps / Line Sizes
- Reaction Tank Issues
Re-Design / Replacement of Absorber Recycle Sprays

- Improve spray density
- Spray coverage improvement
- Fix impingement problems
- Replace end-of-life headers

Replacement / upgrade of the spray headers can result in higher pressure drop and therefore increase power requirements for operation.
WFGD for MATS Compliance

**Improve Scrubber Performance**

Improve spray density/Spray Coverage - requires new header design

*Proper spray pattern design achieves high level of coverage*
WFGD for MATS Compliance

Improve Scrubber Performance

Modify Open Spray Towers

- Absorber Liquid Re-distribution Device (ALRD) or tray addition
- Replace spray headers
- Structural Assessment
Perforated Tray Approach

- Trays provide a bubbling bed of slurry to enhance mass transfer
- Operation of lower L/G saves pump power
- Higher pressure drop costs fan power
- Net power difference (+/-) is site specific and should be determined by specific guarantees

Courtesy B&W
Improve Scrubber Performance
Absorber Liquid Re-Distribution Device (ALRD)

- Developed by MET & patented in 2003
- Increases effective L/G
- Reduces flue gas sneakage
- Re-introduce slurry from walls back into the absorption spray zone
- Increased pressure drop is negligible

United States Patent
Brown et al.
Patent No.: US 6,550,751 B1
Date of Patent: April 22, 2003

GAS-LIQUID CONTRACTOR WITH LIQUID REDISTRIBUTION DEVICE

Inventors: Gregory Norman Brown, Palmyra, PA (US); Raymond Raulfs Gansley, Lebanon, PA (US); Michael Lyn Mengel, Fredericksburg, PA (US); Eli Gal, Lebanon, PA (US)
Assignee: Marsulex Environmental Technologies Corp., Lebanon, PA (US)
Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).
Demonstrated WFGD Enhancements

**ALRD® Upgrade Case Study – USA New Jersey Power Plant**

**Original Design**
- High sulfur Eastern bituminous coal fired (3.2% sulfur)
- Limestone/gypsum system, single absorber tower
- Retrofitted in 1994; designed for 93% SO₂ removal

**WFGD Upgrade**
- Retrofit of two ALRD® levels
- Engineering, procurement and fabrication in 12 weeks
- Designed to enable installation within scheduled outages
System operated to meet the 0.15 lbs SO$_2$/MMBtu after May 1$^{st}$, 2009
Demonstrated WFGD Enhancements

ALRD® Upgrade Case Study

- The upgrade thru installation required 10 months
- Scheduled outages utilized for installation
- No impact on power generation
- System was able to successfully achieve state-required emissions limit
  - Increased SO₂ removal from 93% to 97% at 3.2% S coal
  - Outlet emission of 0.15 lbs SO₂/MMBtu
  - No noticeable increase in pressure drop
  - No change to any of the existing recycle pumps or spray headers

Conclusion

ALRD® technology provides plant operations the ability to improve SO₂ removal efficiency with minimal capital investment.
**PacifiCorp Energy Upgrade**

**2 x 445 MW & 1 X 430 | Lime Based WFGD Upgrade Project**

<table>
<thead>
<tr>
<th>Plant:</th>
<th>Hunter</th>
<th>Huntington</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW:</td>
<td>Units 1,2: 445</td>
<td>Unit 1: 430</td>
</tr>
<tr>
<td>Fuel:</td>
<td>Coal</td>
<td>Coal</td>
</tr>
<tr>
<td>% Sulfur:</td>
<td>1.3%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Inlet Gas Volume: (acfm)</td>
<td>2,065,000</td>
<td>1,906,000</td>
</tr>
<tr>
<td>Reagent:</td>
<td>Lime</td>
<td>Lime</td>
</tr>
<tr>
<td>Absorber Type:</td>
<td>Spray Tower</td>
<td>Spray Tower</td>
</tr>
<tr>
<td>Oxidation Mode:</td>
<td>Forced Oxidation</td>
<td>Forced Oxidation</td>
</tr>
<tr>
<td>SO₂ Removal Efficiency:</td>
<td>Previous: 90%</td>
<td>Previous: 90%</td>
</tr>
<tr>
<td></td>
<td>Upgrade: 95.75%</td>
<td>Upgrade: 95.75%</td>
</tr>
<tr>
<td>Upgrade Startup Date:</td>
<td>Unit 2: 2011</td>
<td>Unit 1: 2011</td>
</tr>
<tr>
<td></td>
<td>Unit 1: 2013</td>
<td></td>
</tr>
</tbody>
</table>

**SO₂ removal efficiency improvement primarily due to ALRD installation**
Improve Scrubber Performance

When ALRD is not enough modify the Recycle Pumps

Increase L of G to Improve SO₂ Removal Efficiency

- Recycle Pump Motor Change
- Impeller Change
- Gear Box Change
- Check External Recycle Piping Size
Improve Scrubber Performance

Reaction Tank Considerations

- With increased SO₂ removal by the system, reaction tank size may not be sufficient for increased absorption.
- With increased SO₂ removal by the system, may have insufficient oxidation air to oxidize from sulfite to sulfate.

Photo courtesy of Ekato
WFGD for MATS Compliance

Mercury Considerations with WFGD

- Wet scrubbers provide high level of oxidized mercury control
- Halogen addition / SCR can boost % oxidized mercury speciation
- Combat mercury re-emission with additives or PAC addition
- Polishing Sorbent Polymer Composite by Gore
- SPC located downstream of the mist eliminators captures both elemental and oxidized mercury
- SO2 reduction is a co-benefit of SPC
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