Results of a Feasibility and Preliminary Engineering Study for a System to Process and Stabilize Scrubber Waste from the APS Four Corners Unit 4 and 5 FGD Systems

Paper #155

Project Background – FCPP 4 and 5

- 2 x 790 MW units
- Units constructed in 1960’s
- 1984 - WFGD and FF added
  - Scrubber sludge thickened and filtered
  - Filter cake blended with ash and trucked to offsite mine for use as mine backfill
- 2004 – Stop offsite mine backfill
  - Thickened scrubber sludge sent to lined impoundment
  - Fly ash sent to dry landfill
  - Portion of ash sold
2012:
- Lined impoundment nearly full. Cannot be expanded.
- Proposed CCR rules expected to encourage dry rather than wet storage of CCR's.
- Original scrubber waste processing equipment in questionable shape (VDF in bad shape).
- URS begins engineering study to identify and evaluate best options for CCR disposal.
FGD Thickener
Ash Silos and Waste Processing Building
Waste Processing Blending Equipment

(pug mill mixers)
Lined Impoundment
Dry Landfill Containing Ash
Big Picture Objective – Can scrubber sludge and ash be blended to produce a material that is stable and suitable for placement in dry landfill?
Is There Enough Ash?

- Coal being fired:
  - Low sulfur sub-bituminous
  - Sulfur content – 0.6 to 1.0%
  - Ash content – 17 to 23%

- Material balance (production rates, lb/hr):
  - Fly ash – 311,656
  - Scrubber solids (90% removal) – 46,644
  - Thickener underflow slurry (36 wt.% solids) – 129,569
Are Properties of Scrubber Solids Suitable for Blending?

- PSD analysis, settling tests and filtration tests suggest that FGD solids have relatively good settling properties for mg-lime process.
- Operation of thickener at higher solids concentration (>36 wt. %) is possible with low cost upgrade of thickener controls.
### What is Optimum Mixture?

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Components</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>78-36-4</td>
<td>Thickener Underflow, Slurry, Fly Ash, and Lime</td>
<td>78wt% Solids in Final Sample. Mix total composition: 34.6% = Thickener Underflow Slurry (36.4wt% solids in the slurry) 61.4% = Fly Ash 4.0% = Lime</td>
</tr>
<tr>
<td>78-36-2</td>
<td>Thickener Underflow, Fly Ash, and Lime</td>
<td>78wt% Solids in Final Sample. Mix total composition: 34.6% = Thickener Underflow Slurry (36.4wt% solids in the slurry) 63.4% = Fly Ash 2.0% = Lime</td>
</tr>
<tr>
<td>78-36-0</td>
<td>Thickener Underflow Slurry and Fly Ash</td>
<td>78wt% Solids in Final Sample. Mix total composition: 34.6% = Thickener Underflow Slurry (36.4wt% solids in the slurry) 65.4% = Fly Ash 0% = Lime</td>
</tr>
</tbody>
</table>
Is Blended Material Suitable for Placement in Landfill?

Tests Performed:
- Penetrometer
- Paint filter
- Atterberg limits (plasticity)
- Tri-axial shear stress
- Unconfined compressive strength
- Hydraulic conductivity / permeability

Placement in Landfill?
### Geotechnical Test Results

**Conclusion:**

Lime addition is not required to obtain material suitable for landfill. Density and strength for the sample without lime are higher than existing fly ash materials placed in landfill.

<table>
<thead>
<tr>
<th>Test Specimen</th>
<th>Unconfined Compressive Strength</th>
<th>Unit Weight&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Atterberg Limits&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Consolidated Unconfined Triaxial Shear</th>
<th>Hydraulic Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample ID</strong></td>
<td><strong>Description</strong></td>
<td><strong>3 Days</strong></td>
<td></td>
<td><strong>9 Days</strong></td>
<td><strong>28 Days</strong></td>
</tr>
<tr>
<td>78-36-1</td>
<td>Thickener Underflow Slurry, Fly Ash, and Lime</td>
<td>18.60 psi @ 1.1% Strain</td>
<td>25.74 psi @ 1.4% Strain</td>
<td>94.2% WC @ 25% MC, dmv = 7.34 psi</td>
<td>LL = 29</td>
</tr>
<tr>
<td>78-36-2</td>
<td>Thickener Underflow Slurry, Fly Ash, and Lime</td>
<td>25.04 psi @ 2.2% Strain</td>
<td>20.86 psi @ 2.1% Strain</td>
<td>97.4% WC @ 25% MC, dmv = 77.5 psi</td>
<td>LL = 30</td>
</tr>
<tr>
<td>78-36-3</td>
<td>Thickener Underflow Slurry and Fly Ash</td>
<td>18.79 psi @ 3.0% Strain</td>
<td>21.07 psi @ 2.9% Strain</td>
<td>97.0% WC @ 25% MC, dmv = 77.5 psi</td>
<td>LL = 27</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Test mixtures prepared by URS
2. LL = Liquid Limits, PL = Plastic Limits, NQ = Not Obtainable, NP = Non-Plastic
3. wet = Wet Unit Weight, mc = Moisture Content, dmv = Dry Unit Weight
Can Plant Continue to Sell Fly Ash?

- Estimated annual fly ash production for Unit 4 and 5 is about 1.23 million tons
- Plant desires to sell 300K tons per year
- 300K tons worth $1.875 million at $6.25 per ton
- Fly ash available for sale after portion used for blending:
  - Thickener underflow = 30 wt.%: 191K tons
  - Thickener underflow = 36 wt.%: 553K tons
PRELIMINARY ENGINEERING
Conceptual Design

- Design assumptions for operation:
  - CCR waste to be placed in landfill will be a mixture of thickened scrubber slurry from thickener and fly ash to obtain a solids concentration of 75 wt.% to 78 wt.%
  - Thickener operated to obtain an underflow solids concentration of 36 wt.%
  - Thickened scrubber slurry and fly ash will be mixed in a pug mill mixer
  - No lime addition to mixed waste
Design Objectives for New Waste System

- Maximize reuse of existing equipment to keep capital costs as low as possible
- Design a system that is easy to operate, reliable and capable of producing a consistent waste material
- Produce a waste material that is acceptable for disposal in a dry landfill and which can be easily handled and transported with low risk for dusting and spillage
- Avoid expense of lime addition
Details of Preliminary Engineering Design

- 50% of existing 6” FRP transfer piping reused, 50% replaced
- Thickener, TUT sludge tank and pug mill mixers refurbished and upgraded
- All pumps except thickener underflow pumps replaced
- New manifold design required to direct slurry from either thickener to any of three pug mill mixers
- New instruments and controls
Process Flow Diagram
Pug Mill Upgrade Design Details

- Modifications to pug mills:
  - Slurry distribution header
  - Mixing curtain downstream of feed chute
  - Current water header to be used as wash header
## Total Project Capital Costs

<table>
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<tr>
<th>Description</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Engineering Services</td>
<td>$943,500</td>
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<tr>
<td>Total Direct Procurement</td>
<td>$1,436,680</td>
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<tr>
<td>Total Construction Management Services</td>
<td>$388,500</td>
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<tr>
<td>Total Construction</td>
<td>$2,217,836</td>
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<tr>
<td>Project Contingency (15%)</td>
<td>$705,517</td>
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<tr>
<td>Total EPCCM Project Cost</td>
<td>$5,692,033</td>
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</tbody>
</table>

*URS*

5-Jun-12

*Four Corners Sludge Project*

*URS Project Number 23446139*
Comparison of Alternative Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blending system as designed</td>
<td>$5.7 MM</td>
</tr>
<tr>
<td>Blending system as designed with new pug mill mixers</td>
<td>$6.8 MM</td>
</tr>
<tr>
<td>New 250 acre double-lined ash pond with leak detection</td>
<td>$60 - $70 MM</td>
</tr>
<tr>
<td>ZLD system*</td>
<td>$85 – 95 MM</td>
</tr>
</tbody>
</table>

*Assumes scrubber solids are dewatered and ZLD technology (phys-chem treatment, RO-brine concentrator, crystallizer) used to treat liquid discharge.
Study Conclusions

- Blending of thickened scrubber sludge and fly ash at a solids concentration of 75 wt.% to 78 wt.% will produce a material that is acceptable for placement in a dry landfill. The material will actually have superior geotechnical properties than material currently being placed in landfill.
- Use of lime to stabilize the waste material is not necessary.
- The proposed system makes maximum reuse of existing plant equipment.
- Operation of the new system should be easy and reliable and produce a waste material with consistent physical and chemical properties.
Plant can continue to sell fly ash at current levels. Design operation will allow ash sales to increase to 553K tons per year.

The proposed modifications to equipment will improve mixing and significantly reduce dusting and spillage during handling and transport.

The discharge of liquid purge water from the FGD system in the waste will be more than sufficient to allow the plant to operate as ZLD,
- 167 gpm; 239,783 gpd
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