Shake, Rattle and Roll
Enhancing Solids Mixing

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Presentation Overview

- Solids Review
- Storage and Mixing Considerations
- Enhancing Mixing Case Studies
  - Shake: Chopper Pump and Nozzles
  - Rattle: Jet Mix and Nozzles
  - Roll: Linear Motion
- What we learned
Where do solids come from?

5 Steps to Clean Water

1. Preliminary Treatment: Bar Screening
2. Primary Treatment: Settling Tank
3. Secondary Treatment: Aeration & Sedimentation Tanks
4. Advanced Treatment: Filtration
5. Disinfection: Chlorine or Ultraviolet

Solids removed during the treatment process can be further treated and safely used for other applications, such as fertilizer.

Clean water is returned to the ocean, lake, river, or stream.

Clean water is used for a variety of purposes, such as irrigation.
Types of Solids

- Primary Solids
- Return / Waste Activated Solids
- Co-settled (Primary + WAS)
- Thickened (TWAS)
- Digested (Aerobic, Anaerobic)
- Dewatered (Cake)
- Alkaline (Lime + Solids)
- Incinerated (Ash)
Primary Solids

- 2% to 8% Total Solids
- 60% to 80% Total Volatile Solids
- Impacted by
  - CSO/SSO (I&I, grit)
  - Industrial influence (BOD, metals)
  - Screening and grit efficiency
- Typically requires grinding
- Tend to wear on pumps
  - Impellers, diaphragms or rotors and stators
- Typically inefficient pumping
Waste Activated Solids

- 0.4% to 1.2% Total Solids
- 60% to 85% Total Volatile Solids
- Impacted by
  - Primary treatment?
  - Type of Aerobic Treatment
    - Conventional aeration, trickling filters
  - Nutrient removal
    - Higher N or P content in solids
Co-settled / Thickened Solids

- WAS difficult to dewater
- Co-settled
  - WAS combined in primary tanks
  - Primary → WAS properties
- Thicker is Normally Better
  - Less Water Volume to treat later
    - Recycle pumping (diverted earlier)
    - Digester heating
    - Higher solids overall (less water disposal)
Why Solids are Important

- Each WWTP is Different
  - Even similar processes vary plant to plant
  - Equipment, operations, recycle impacts, water usage, etc.
- Solids are Unique
  - Not just concentration (TS vs TSS)
  - Also account for flow rate and load

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Flow</th>
<th>Wet Load</th>
<th>Dry Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>10 wet gal/min</td>
<td>83 wet lbs/min</td>
<td>0.8 dry lbs/min</td>
</tr>
<tr>
<td>1%</td>
<td>100 wet gal/min</td>
<td>830 wet lbs/min</td>
<td>8.3 dry lbs/min</td>
</tr>
</tbody>
</table>
Why Store Solids?

- Solids are produced continuously
- All ops, all the time, 24/7? Not usually
- When transferring solids, consider:
  - Treatment hours of operation
  - Scheduled maintenance downtime
  - What about un-scheduled maintenance?
- Storage Flow Control
  - Provides “wide-spot” in treatment
  - Flexibility in feed rates to equipment
  - More control to improve performance
Storage Design

• Considerations
  • Material: concrete, metal, plastic
  • Bottom: flat, cone, slope to drain
  • Cover, support, wall height and thickness
  • Scum, foam, decant, overflow connections

• Rectangular Tanks
  • Easy to frame and build, corners do not mix

• Circular Tanks
  • No corner issues, cannot share walls

• Special design and construction
  • Egg shaped digesters
Why Mix Solids?

- Several sources, different times → same tank
  - Variations in %solids
  - Settling and/or stratification in tank
- Mix to provide blended / consistent solids
  - Enhances storage with stable feed downstream
  - Better equipment performance
- Wonderful side effects
  - Minimizes grit and solids accumulation in tanks
  - Less storage volume lost to accumulation
  - Uniformly distributes heat with solids (digestion)
Mixing Considerations

- Transfer electrical/mechanical energy to liquid
  - Keep solids in motion and suspension
- Type of solids impacts mixing
  - Rags, grit, variations in % solids
  - Will shaft or pump be impeded by solids content?
- Not all mixing technologies are the same
  - Each technology has application
  - Not all suited for every application
- Example
  - High % solids = sludge multiplication factor
  - Much more energy required to mix
Mixing Technologies

- Mechanical (turbine) mixing
  - Top/side mounted
  - Draft tube or submersible
- Pumped mixing
  - Piped intake to pump, discharge nozzles in tank
- Aeration mixing
  - Air blowers and gas diffusers
  - Prevents septic conditions
  - Prevents nutrient release
  - Minimizes odors
Why change storage/mixing?

- Equipment age, high O&M cost
- Life Cycle cost savings (payback period)
- Newer technology may be more efficient
  - More effective mixing
  - Less horsepower
- Consider non-cost factors
  - Performance
  - Maintenance
  - Flexibility / Adaptability
  - Noise / Odors
Case Study: Shake

Let’s Shake it Up!
Case Study: Shake Background

- Existing rectangular concrete tanks (2 of 6)

<table>
<thead>
<tr>
<th>Tank Info</th>
<th>Tank T-601A</th>
<th>Tank T-602</th>
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</thead>
<tbody>
<tr>
<td>Inside Length, feet</td>
<td>44.3</td>
<td>31.5</td>
</tr>
<tr>
<td>Inside Width, feet</td>
<td>44.3</td>
<td>28.5</td>
</tr>
<tr>
<td>Water Elevation, feet</td>
<td>19.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Volume, gallons</td>
<td>278,000</td>
<td>141,000</td>
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</table>

- Solids = Combined primary (6%) and TWAS (0.8%)
- Blending (4.3%) storage tanks → dewatering
- Total Solids Load (MM, future)
  - 53,430 dry ppd primary + 33,680 dry ppd TWAS
- Total Flow: you can do the math!
Case Study: Shake Issues

- Existing mixing = Top-mount mechanical turbine
- Inconsistent solids, poor mixing, aged equipment
- Taking up valuable working / courtyard space
Consider new mixing (not turbine mechanical)

Pumped mixing – Vaughan Rotamix
  - Chops while it mixes
  - Nozzles provide energy to stir tank

Air Diffuser mixing – Tideflex
  - Provides mixing and some aeration
  - Keeps from going septic
  - Minimizes odors

Already have odor control on tank air

Concerns about tank entry for maintenance
Case Study: Shake Selection

- Vaughan Rotamix Selected
- Easy to retrofit existing tank
Case Study: Shake Benefits

- Mechanical Mixer $55k capital, 20 HP motor
- Rotamix Pump $30k capital, 25 HP motor
  - $25k capital savings for Rotamix
  - 3.7 kW more for Rotamix
  - 5 days, 24 hrs / week, $0.075/kWh
  - $468 / yr / kWh
  - $1,730 / year more for Rotamix
  - Saved capital covers over 14 years of HP cost
- Less maintenance, resolved mixing issues
- More Importantly, Owner Happy with Install
Case Study: Rattle

Battle for the Rattle!
Case Study: Rattle Background

- New rectangular concrete tank (1 of 2)

<table>
<thead>
<tr>
<th>Tank Info</th>
<th>Tank A</th>
</tr>
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<tbody>
<tr>
<td>Inside Length, feet</td>
<td>46.0</td>
</tr>
<tr>
<td>Inside Width, feet</td>
<td>32.9</td>
</tr>
<tr>
<td>Water Elevation, feet</td>
<td>13.3</td>
</tr>
<tr>
<td>Volume, gallons</td>
<td>151,000</td>
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<tr>
<td>WAS Solids Flow, gpd</td>
<td>39,000</td>
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<tr>
<td>Storage Time, days</td>
<td>3.9</td>
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- Solids = WAS (0.75%)
- Long storage times require minimum DO
- Aerated storage tanks → dewatering
Case Study: Rattle Jet Aeration

- Consist of:
  - In-basin FRP liquid and air headers
  - Jet nozzles for mixing liquid and air
  - Back-flush system
  - Solids recirculation pump
  - Air blower
Case Study: Rattle Design

- Solids recirculation pump (screw centrifugal)
- Air blowers (PD)
- Back-flush system (unplug nozzles)
Case Study: Rattle Design (cont.)

- Manufacturer input required
  - Location of header in tank
  - Liquid and air header sizing
  - Liquid flow / nozzle
  - # of nozzles, angle and distance between
  - Jet Aeration Performance
    - SCFM / nozzle and oxygen transfer efficiency
    - Several site dependent criteria
- Mixing should induce flow pattern in tank
- Mixing Energy at least 100 HP/MG

\[
\text{Tank Liquid Flow (gpm) x Nozzle Headloss (feet)} \\
\text{3960 x Tank Volume}^{1} \text{ (MG)}
\]
Case Study: Rattle Final Design

- 12” liquid and 6” air header
- 400 gpm / nozzle, 8 nozzles
- 30 degree down angle for floor turbulence
- 391 SCFM for air flow (19.3 SCFM/1000 CF)

Mixing Energy
- 20.3’ nozzle headloss
- 0.15 MG tank volume
- 3,200 gpm flow
- 110 HP / MG (at nozzle)

Solids Pump
- 3,200 gpm, 24’ TDH, 75% Efficient
- 30 HP each (~150 HP/MG delivered)
Case Study: Rattle Remembered

- Not your typical solids mixing design
  - Solids pumping (HP/MG)
  - Air blower design (SCFM and Oxygen Transfer)
  - Jet aeration design (varies by manufacturer)
- Work closely with manufacturers
  - Several manufacturers out there
  - Include minimum key components
  - Verify criteria critical to design
  - Coordinate components with each manufacturer
  - Weed out the subpar
- Construction still underway...
Case Study: Roll

Keep on Rolling!
Case Study: Roll Background

- Existing circular concrete tank
  - Solids = Co-settled Primary + WAS (3%)
  - Anaerobic digester tank → dewatering
  - Existing draft tube mixer
  - Replace in-kind
  - New mechanical turbine mixer
  - New Linear Motion “LM” mixer (OVIVO)

### Tank Info

<table>
<thead>
<tr>
<th>Tank Info</th>
<th>Tank A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside Diameter, feet</td>
<td>60.0</td>
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<tr>
<td>Water Elevation, feet</td>
<td>24.0</td>
</tr>
<tr>
<td>Volume, gallons</td>
<td>508,000</td>
</tr>
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</table>
Case Study: Roll LM Mixer

- Explosion Proof Motor – Gearbox
- Drive Shaft
- Drive Support
- Mixer Flange
- Seal Tube
- Shaft
- Hydro-Disk
**Case Study: Roll Comparisons**

<table>
<thead>
<tr>
<th></th>
<th>Draft Tube</th>
<th>Turbine Mixer</th>
<th>LM Mixer</th>
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<tbody>
<tr>
<td><strong>Capital Cost</strong></td>
<td>$51k</td>
<td>$46k</td>
<td>$103k</td>
</tr>
<tr>
<td><strong>Annual O&amp;M Cost</strong></td>
<td>$12k</td>
<td>$9k</td>
<td>$5k</td>
</tr>
<tr>
<td><strong>Motor HP</strong></td>
<td>10 x 2</td>
<td>5 x 2</td>
<td>7.5 x 1</td>
</tr>
<tr>
<td><strong>Redundancy</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>Below Lid</td>
<td>Above lid</td>
<td>Above lid</td>
</tr>
<tr>
<td><strong>Concerns</strong></td>
<td>Energy O&amp;M cost</td>
<td>Shaft deflection O&amp;M cost</td>
<td>Relatively new technology</td>
</tr>
</tbody>
</table>

- **LM Mixer Selected – Most Energy Efficient!**
- **Despite higher capital, lower O&M yields payback**
  - $103k-$51k = $52k, $7k annual savings, in 8 years
Case Study: Roll Design Notes

- Digester mixing criteria
  - Turnover rate
  - Power/volume ratio
  - Minimum velocities
- Coordinate with manufacturer
  - Biomass-substrate contact
  - Distribute buffering alkalinity pH control
  - Prevent stratification
  - Homogeneous digested solids
  - Evenly distribute temperature
- Mixing intensity?
  - Beware grit accumulation issues
  - Not suspending denser particles?
  - Scouring velocities too low?
Replacement performed by plant staff
- Store/haul solids during installation
- Gas handling while digester offline
- Safety First! (confined space work)
- Despite prep & planning still some issues during install
- Recommend mock installation

Up and running now
- Slight improvement in volatile solids reduction
- Gas production increased
- No reports of grit accumulation issues
Effective storage and mixing is critical to solids treatment and disposal

- From “wide spot” flow control
- To un-stratified even mixtures

Considerations for mixing technology

- Every application is unique
- Not every mixing technology applies
- Not every manufacturer is the same
- Factor Life Cycle and non-cost input

Make the Owner Happy with Installation
Questions?

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