REHABILITATION AND OPTIMIZATION OF ANAEROBIC DIGESTION MIXING SYSTEMS

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Presentation Outline

- Existing Digester Mixing Systems
- New Digester Mixing Systems
- Mixer Advantages and Disadvantages
- Digester Mixing System Evaluation
- Design Considerations
- Beneficial Uses of Sludge Gas
- Energy Cost Considerations
- Questions and Answers
Existing Digester Mixing Systems
Gas Lance Mixing System
Pump Recirculation

Multi-Duty 7.5-HP Circulating Sludge Pumps
New Digester Mixing Systems
Jet Mixing System

Advantages
- Low capital cost

Disadvantages
- Nozzle clogging
- No back-up
- Requires grinder
- High energy demand
External Draft Tube Mixers

Multiple external draft tube mixers are placed around perimeter of digester

- **Advantages**
  - Proven technology
  - Heat exchange jackets for low cost digester heating
  - Maintenance access exterior to digester
  - System can reverse direction
  - Back-up

- **Disadvantages**
  - Require a crane for maintenance
  - Capital costs
  - Upper discharge pipe limits travel distance for floating covers

Eimco
External Draft Tube Mixer Installation
Vertical Linear Motion Mixers

Advantages
- Low energy demand
- Low capital cost
- Low maintenance, easy access

Disadvantages
- Newer technology for digester mixing
- No back up

Works on displacement

Literature shows comparable to draft tubes

Eimco
Gas Cannons

- **Advantages**
  - Less energy demand
  - Redundancy

- **Disadvantages**
  - Gas compressors
  - Bubble generator inside digester

- Large bubbles every 3-4 seconds
- 14 24-inch diameter, 18’ long mixers for 110’ diameter
Digester Mixing System Evaluation
Relative Mixing Technology Cost Comparison*

Mixer Capital Cost

Mixer Energy Cost

*Based on 110’ Diameter Digester

Relationships may vary depending on manufacturer and digester size.
Digester Performance Evaluation

Volatile Solids Reduction (%)

1998
2011
Digester Performance Evaluation

Bar graph showing specific biogas production rates per LB, comparing Fed and Degraded conditions for 1998 and 2011.
16% Increase in VSS Destruction

Over 5.0 Million CF of Additional Digester Gas Produced on an Annual Basis

Improved Mixing Targeting Hydrophobic Solids Resulting in Higher Gas Production

More Consistent SRT’s through Elimination of Short Circuiting

More Consistent Temperature Control
Design Considerations
### Design Considerations – Basis of Design (110’ dia)

<table>
<thead>
<tr>
<th>Mixer Type</th>
<th>Unit Horsepower</th>
<th>HP Per Digester</th>
<th>System Power Consumed (KW)</th>
<th>Turnover Time (minutes)</th>
<th>Unit Flow Rate (gpm)</th>
<th>Digester Flowrate (gpm)</th>
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<tbody>
<tr>
<td>External Draft Tube Mixer</td>
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<td>40.0</td>
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<td>9.4</td>
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Design Considerations – Cover Types

**Digester Covers**
- Fixed Cover

**Gas Holder Covers**
- Membrane Covers
- Floating Covers

**Floating Covers**
Greater Reliance on Gas Conditioning

- Moisture Removal
- H$_2$S Removal
- Siloxane Removal
- Gas Pressure Boosting
Hydrogen Sulfide, ppmv

Siloxanes, mg/m^3

Siloxane Damage

Engine H₂S Limits

uTurbine & Fuel Cell H₂S Limits

Engine Siloxane Limits

uTurbine & Fuel Cell Siloxane Limits

Digester Gas Conditioning
Gas Conditioning Unit
Digester Gas Heat – Consider All Heating Loads
Design Considerations – Electrical Improvements
Beneficial Uses of Sludge Gas
System Alternatives

Thermal Only
- Boilers
- Absorption Chillers

Combined Heat and Power
- IC Engine-Generators
- Microturbines
- Fuel Cells
- Prime Movers
Energy Cost Considerations
Value of Equivalent Natural Gas

- +5,884,385 Additional CF @ 600 BTU/CF=
- 35,306 Therms @ $1.00/Therm=
- $35,306/Yr Natural Gas (NG) Equivalent
- As much as 80% can be recovered in boilers, for an annual NG savings of $28,245

- If this gas is used to fire a combined heat and power system with 30% mechanical and 30% electrical efficiency, at an $.08/kWh electric rate, the annual NG and electricity costs replaced could be as much as $38,060
Statistical Thermal & CHP Energy Modeling

Heating Loads: MBH in Each Outside Air Temperature Bin

- Digester
- Building
- Total
- DG Boiler
- uTurbine

OUTSIDE AIR TEMPERATURE: °F

PLANT HEATING LOAD: BTU/Hour x 1,000
Hourly Thermal & CHP Energy Modeling
Heating Loads Calculated for each Hour of Occurrence

South Bend, Indiana
TMY3 (Typical Meteorological Year) Data
National Solar Radiation Database
U.S. National Renewable Energy Laboratory
Additional Energy from increased DG production. Burned In DG boilers reduces annual NG cost 12% or more.

Natural Gas Savings With
DG Boilers = $156,720

Without DG boilers = $254,450

Natural Gas Cost
Without DG Usage = $254,450

Natural Gas Savings With DG Boilers = $156,720

(Additional Energy from increased DG production.)

Burned In DG boilers reduces annual NG cost 12% or more.
Benefits: Why External Draft Tube Mixers?

- Very accurate temperature control
- Minimized solids settling
- Reduced digester cleaning maintenance
- Elimination of digester heat exchanger cleaning
- Reduced chance of process ‘upsets’
- Superior heating and mixing reliability and redundancy
- Savings percent potentials extend, to a greater extent, to FOG & other digester feed supplements
- Increased digester gas production
- Reduced electrical mixing energy usage compared to most alternatives
Questions and Answers