DIGESTION EXPERTISE

- WEFTEC 1997-2001

... recognized as the industry leader in aerobic digestion and thickening at high solids concentrations
Membrane Thickening Digestion

- Aerobic digestion process using a Flat Plate Membrane Unit

Ideal for:

Facilities obligated to meet stringent nutrient discharge limits, specifically total nitrogen and phosphorus

Decentralized facilities or Reduced operations staff

Class B Applications
How Does Membrane Thickening Work?

- How Does Sludge Get Thickened With a Membrane?

- A membrane thickening (MBT) submerged unit is used to create a physical barrier across which to extract clear water from sludge.
- Air diffuser incorporated on the lower part of the cassette.
Membrane Thickener Key Ingredients

**Key Ingredients**

- **Flux** = Rate of filtration per unit area of membrane material. Since thickening is typically three times more than an MBR process, flux rates are significantly lower.
  - MBR flux @ 20°C = 17.2 gfd vs MBT flux @ 20°C = 5.1 gfd
- **Transmembrane Pressure (TMP)** = The pressure across the membrane during filtration.
  - Typical TMP at design flux rates = 0.5 to 0.75 psig
  - Maximum TMP = 3.0 psig
- **Air Scour** = Air flow required to scour membranes to prevent fouling.
- **Biofilm** = Complex dynamic of microorganisms. The interdependency between biological process conditions and membrane filtration performance through a biofilm is termed *BioHydraulics*
The Importance of Biofilm

- **Biofilm Basics**
  - **YOU DON’T GET TO CHOOSE:** All submerged membranes have a biofilm. As soon as filtration starts and biological solids are brought to the membrane surface, biofilm formation occurs.
  - **Benefits**
    - Biofilm serves as a secondary dynamic filter and represents a changing to filtrate flow.
    - Create a dense secondary membrane that can allow for enhanced nutrient removal and degradation of refractory organics.
  - **Biofilm management is the key to operating a successful membrane thickening system.**
Biofilm Conditions

- Ideal
- Stable TMP
- Non-Uniform
- High TMP
- Increased TMP
- Variable TMP
- High TMP
Biofilm Conditions

GOOD

BAD
Membrane Thickener Facts

- Membrane Thickener

- Flat Plate Membrane Thickener Facts
  - PE membrane ultrasonically welded to ABS plate.
  - Nominal pore size 0.4 micron, effective pore size 0.1 micron
  - Effective air filtration area 8.6 ft\(^2\) per cartridge
  - MBT Design flux 5 gfd @ 20° C
  - MBT Cross flow velocity is 2.25 ft / sec
Minimum Maintenance Requirements

- Automated Diffuser Cleaning, approximately 30 min/day
- Membrane Relax, approximately 1 min/10 min
- Chemical Cleaning, in-situ cleaning every 6 months, approximately 2 hour duration

NO NEED TO DRAIN TANKS OR TAKE OUT OF SERVICE FOR CHEMICAL CLEANING.
Why use a Membrane Thickening Process

Operational Benefits of Membrane Thickening

1. Improved and Reliable Thickening

Polymer and Decanting
Why use a Membrane Thickening Process

Operational Benefits of Membrane Thickening

SO……

Polymer and Decanting

= Reduced Operator Attention
Why use a Membrane Thickening Process

Economic Benefits of Membrane Thickening

2. Reduced Footprint

- Class B Stabilization in a Reduced volume
- Reduced Tanks Sizes and Ideal for Retrofits
- Less air requirements/energy usage.

Digestion with Membrane Thickening

Traditional Digester
Why use a Membrane Thickening Process

Process Benefits of Membrane Thickening

3. Produces a High Quality Permeate that features:
   - Minimal Total N and P without chemical addition
   - Reuse quality that can be recycled to head of plant or sent to disinfection
   - Protects effluent quality of BNR Process
Aerobic Digestion Processes vs Activated sludge processes

Aerobic Digestion is a **biological process** similar to Activated Sludge.

Activated Sludge = Growth

Aerobic Digestion = Decay
Aerobic Digestion Processes vs Activated sludge processes

Practical Approach To Help Understand the Difference!

Activated Sludge

Aerobic Digestion
Aerobic Digestion Chemistry

1. Digestion:
\[ \text{C}_5\text{H}_7\text{NO}_2 + 5\text{O}_2 = 4\text{CO}_2 + \text{H}_2\text{O} + (\text{NH}_4\text{HCO}_3) \]
\[ \text{Biomass} \quad \text{Ammonium Carbonate} \]

2. Nitrification:
\[ \text{NH}_4^+ + 2\text{O}_2 = \text{H}_2\text{O} + 2\text{H}^+ + \text{NO}_3^- \]
\[ \text{Ammonia} \quad \text{Acid} \quad \text{Nitrate} \]

3. Digestion with Nitrification:
\[ \text{C}_5\text{H}_7\text{NO}_2 + 7\text{O}_2 = 5\text{CO}_2 + 3\text{H}_2\text{O} + \text{HNO}_3 \]
\[ \text{Biomass} \quad \text{Nitric Acid} \]
Aerobic Digestion Chemistry

4. Digestion with Nitrification:
\[ \text{C}_5\text{H}_7\text{NO}_2 + 7\text{O}_2 = 5\text{CO}_2 + 3\text{H}_2\text{O} + \text{HNO}_3 \]
Biomass \hspace{1cm} \text{Nitric Acid}

5. Denitrification:
\[ \text{C}_5\text{H}_7\text{NO}_2 + 4\text{NO}_3^- + \text{H}_2\text{O} = \text{NH}_4^+ + 5\text{HCO}_3^- + 2\text{N}_2 \]
Biomass \hspace{0.5cm} \text{Nitrate} \hspace{1cm} \text{Ammonia} \hspace{1cm} \text{N Gas}

6. Complete Nitrification / Denitrification:
\[ \text{C}_5\text{H}_7\text{NO}_2 + 5.75\text{O}_2 = 5\text{CO}_2 + 3.5\text{H}_2\text{O} + 0.5\text{N}_2 \]
Biomass \hspace{1cm} \text{N Gas}
Membrane Thickening Aerobic Digestion Process

- Influent WAS
- Anox. Basin
- MBT
- Permeate
- Digester 1
- Digester 2
- Digested Sludge
Case Studies

Case Studies Membrane Thickening Aerobic Digestion Processes
Dundee WWTP, Michigan

First U.S. Installation
Dundee WWTP, Michigan

Commissioned: 2005
Liquid Process: MBR (1.2 MGD)
MBT Size: 800 plates
Solid Conc.: 3%-5.25%
Chemical Cleaning: 2-3 / year (scheduled)
Dundee WWTP, Michigan

Engineer: Arcadis

History:
- Objective was to reduce the hauling to 2 times per year. Tanks are designed to store 180 days at 3% solids.
- Operator friendly when compared to other systems.
Dundee WWTP, Michigan

Thickening Performance
Sep & Oct 2005 Operation

% solids

Date

WAS
MBT Thickener
Digester #1
Digester #2
Dundee WWTP, Michigan

September 2005 to June 2008 Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>BOD</td>
<td>1.12 mg/l</td>
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<tr>
<td>TSS</td>
<td>2.00 mg/l</td>
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<tr>
<td>NH$_3$-N</td>
<td>0.22 mg/l</td>
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<tr>
<td>NO$_3$-N</td>
<td>0.03 mg/l</td>
</tr>
<tr>
<td>TP</td>
<td>1.09 mg/l</td>
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### Dundee WWTP, Michigan

#### Sludge Hauling Cost Summary

<table>
<thead>
<tr>
<th>Years</th>
<th>Gallons Hauled</th>
<th>Dry Tons</th>
<th>Yearly Cost</th>
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<tbody>
<tr>
<td>2004 (0.6 MGD)</td>
<td>248,885 – Belt</td>
<td>22.67 – Belt</td>
<td>$16,850 – Belt</td>
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<tr>
<td></td>
<td>1,192,100 - Total</td>
<td>122.06 - Total</td>
<td>$46,938 - Total</td>
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<tr>
<td>2005 (1.2 MGD)</td>
<td>572,400 – Belt</td>
<td>55.62 – Belt</td>
<td>$39,135 – Belt</td>
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<tr>
<td>MBT operational</td>
<td>432,000 – MBT</td>
<td>47.55 – MBT</td>
<td>$14,623 – MBT</td>
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<tr>
<td>for 2nd half of</td>
<td>1,004,400 - Total</td>
<td>103.17 - Total</td>
<td>$53,758 – Total</td>
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<tr>
<td>year only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>887,400 - MBT</td>
<td>130.48 – MBT*</td>
<td>$32,739 - MBT</td>
</tr>
</tbody>
</table>

**Belt press was needed for years 2003 -05 due to lack of storage space.**

**Sludge Hauling costs for first full year of operation of MBT in 2006 was $32,739 which is cheaper than the last 5 years**

* Sludge Production minimized due to N/DN
McFarland Creek WWTP, Ohio

Engineer: CT Consultants

Two Stage Membrane Thickening Aerobic Digestion Process
McFarland Creek WWTP, Ohio
Membrane Units Installed Directly Inside the Digesters
McFarland Creek WWTP, Ohio

Commissioned: 2005
Waste Type: Municipal
Liquid Process: MBR (1.8 MGD)
MBT Size: 400 plates
Solids Conc.: 3.5%-5.5%
Membrane thickening at McFarland Creek WWTP was able to thicken up to 5% solids.
McFarland Creek WWTP, Ohio

McFarland Creek WWTP Improved Dewatering Operations

Annual BFP run time w/o PAD®-K 8,736 hours
Annual BFP run time with PAD®-K 3,744 hours
Reduction BFP run time 57.14%

MORE EFFICIENCY MEANS BETTER RESULTS

41% Reduction in CUBIC YARDS PRODUCED
36.5% Reduction in DRY TONS PRODUCED
41% Cost Reduction in POLYMER
41% Cost Saving in SLUDGE DISPOSAL
Woodside WWTP, New York

**Biological Process:** Concentric Circular Plant

**GOAL:** Reduce Number of Sludge Hauling Trips

Less gallons to haul per year:
- Sludge hauling reduction: 625,783 gal.
- Savings per year: $59,449

ROI of 2.57 years based solely on hauling
Cayce WWTP, South Carolina

Engineer: American Engineering Consultants

Membrane Thickening Digestion Following a Carrousel Biological Process: Coming To A Theatre Near You

Current Site
8 MGD Cap.
To be expanded to
25 MGD

Membrane Thickening
Digestion selected
to protect BioP
Carrousel Ditch
Cayce WWTP, South Carolina

Cayce WWTP Carrousel MD Process

Start-up Plant Flow = 8 MGD
Intermediate Plant Flow = 12 MGD
Design Influent Plant Flow = 25 MGD
WAS concentration = <10,000 mg/l
Design digestion SRT = 20 days

Membrane modules in Series
Cayce WWTP, South Carolina

Benefits

- Eliminated construction of thickener building.
- Reduced number and size of digesters by operating at 4% TS.
- Provided flexibility for a gradual flow increase.
- Reduced O&M costs by eliminating use of polymer for thickening.
- Reduced O&M costs due to less aeration / energy needs.
- Reduced O&M costs due to less supervision needs.

SAFE GUARD HIGH QUALITY BIO-P CARROUSEL EFFLUENT
Conclusions

MEMBRANE THICKENING AEROBIC DIGESTION PROCESSES BRING:

**ECONOMIC VALUE:**
- Reduced Tank Sizes and Ideal for Retrofits
- Savings on Energy, Disposal, Chemical, and Concrete Costs

**PROCESS VALUE:**
- Class B Stabilization
- Reuse Quality Permeate with Low Total N and P
- Odor Control
- Increased Solids Storage Capacity in existing or new tanks

**OPERATIONAL VALUE:**
- Reduced Operator Attention
- Thickening Without Polymers
- No Attention to Decanting
Any Questions?

ANY QUESTIONS?
Thank You
THAT’S ALL FOLKS!

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