Anaerobic Digester Rehab: Real World Trials & Tribulations

Tom Crouse
Craig Hendrickson
Eau Claire, WI Wastewater Utility

- Located ~ 85 miles East of Twin Cities, in Heart of Wisconsin

- Wastewater Utility
  - Serves Cities of Eau Claire and Altoona
    - Service Population ~75,000
  - WWTP
    - Average Daily Flow 5 mgd
    - 2030 Design ADF 6.8 mgd
    - Last Major Upgrade 1980
Eau Claire WWTF

Facility treats an average daily flow of 6 MGD with an average capacity of 11.5 MGD and peak capacity of 30 MGD.

RED = New
GREEN = Existing
YELLOW = Removed
2006-2007 Facility Planning

Recommendation: Phased Upgrade

- Phase 1: Address Critical Needs
  - Additional Biosolids Storage Tank
  - Major Pump Station Upgrade
  - Effluent pH Adjustment System
  - ~$4.5 M Cost, Constructed 2007-2008
  - Allow City to Adjust User Rates for Phase 2 Upgrade

- Phase 2: Address 20 Year Planning Period Needs
  - “expected to be required within next 5-10 years due to age of and potential failure of RBC units”
Phase II of Project

The facility improvements were as follows:

- Odor control using a self-sustaining bio-filter
- Replace RBC process with activated sludge
- Upgrade solids handling and digestion process
- Digester gas utilization for electrical energy production
- Heat recovery from effluent and gas engines
- Automation of facilities for process efficiency and daytime operation
- Security and fire alarm systems
- Efficient lighting of site with management control
- Energy management system
- Upgrade laboratory, process buildings and administration/maintenance facilities.
- Upgrade heating and ventilation systems
- Replacement of pumps air blowers and motors with more efficient units.
- Replacement of electrical power system and add standby power generation
Major Elements of Phase 2

- Nitrifying Activated Sludge
  - With Biological Phosphorus Removal
  - Rehab Secondary Clarifiers
- Sludge Thickening Improvements
  - New GBTs & Sludge Pumps
- Anaerobic Digestion Improvements
  - Covers, Mixing, Heating
  - New Biogas Engine Generators
- Design Complete & Construction Began 2013
Major Players

- CD Smith – General
- JF Ahearn – Mechanical
- Total Electric – Electrical
- Precision – Underground
- City of Eau Claire – Owner
- Donohue - Engineer

- 3 year project
- Weekly meetings
- Monthly meetings
- Good relationship
Digester Work

- In the order of 3, 1 and 2, then 4
- This included the following components associated with each digester:
  - Digester cleaning.
  - Digester cover “rehab”.
  - All interior piping removals and installations.
  - Digester mixing systems.
  - Digester Recirculation Pump.
  - Digester Heat Exchanger.
  - Digester gas piping.
Digester No. 1

Maximum Water Level

Minimum Water Level

Maximum Water Level

Minimum Water Level

Digester No. 1
Linear Motion Mixer

- 7.5 hp
- 460 volt

Digester 1 & 2
- 60 ft diameter
- 500,000 gallons
Digesters 3 & 4

Digester 3 & 4
100 ft diameter
2,085,000 gallons

100 hp
460 volt

100 hp
460 volt
Planning

- To G308 #4
- Skirt
- Dig #4
- Water
- High level
- Low level = 1.8 Million
- Floor
- 09/30/2014 06:42
- Items A
Digester Operation Prior to Project

Raw Sludge

1
2
3
4
## Digester Operating Data

### Digester Operation

#### 2013 Monthly Average Data

<table>
<thead>
<tr>
<th></th>
<th>Digester 1</th>
<th></th>
<th>Digester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HRT days</td>
<td>VS Ld</td>
<td>HRT days</td>
</tr>
<tr>
<td>January</td>
<td>18.0</td>
<td>0.048</td>
<td>18.0</td>
</tr>
<tr>
<td>February</td>
<td>17.8</td>
<td>0.044</td>
<td>17.8</td>
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<tr>
<td>March</td>
<td>17.2</td>
<td>0.059</td>
<td>17.2</td>
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<tr>
<td>April</td>
<td>16.5</td>
<td>0.058</td>
<td>16.5</td>
</tr>
<tr>
<td>May</td>
<td>16.0</td>
<td>0.057</td>
<td>16.0</td>
</tr>
<tr>
<td>June</td>
<td>17.8</td>
<td>0.043</td>
<td>17.8</td>
</tr>
<tr>
<td>July</td>
<td>17.8</td>
<td>0.049</td>
<td>17.8</td>
</tr>
<tr>
<td>August</td>
<td>18.3</td>
<td>0.050</td>
<td>18.3</td>
</tr>
<tr>
<td>September</td>
<td>18.4</td>
<td>0.054</td>
<td>18.4</td>
</tr>
<tr>
<td>October</td>
<td>18.4</td>
<td>0.053</td>
<td>18.4</td>
</tr>
<tr>
<td>November</td>
<td>17.1</td>
<td>0.050</td>
<td>17.1</td>
</tr>
<tr>
<td>December</td>
<td>18.1</td>
<td>0.046</td>
<td>18.1</td>
</tr>
</tbody>
</table>

### Theoretical Digester Data

#### Single Primary Digester Data

<table>
<thead>
<tr>
<th></th>
<th>HRT Days</th>
<th>VS Ld</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg</td>
<td>8.8</td>
<td>0.102</td>
</tr>
<tr>
<td>Min/Max</td>
<td>8</td>
<td>0.132</td>
</tr>
</tbody>
</table>

Recommended minimum HRT is **12 days**

=&gt; Max Month Loading Conditions
Theoretical Primary Digester Data

<table>
<thead>
<tr>
<th>HRT Days</th>
<th>VS Ld lb/d/cf</th>
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<tr>
<td>Avg 8.8</td>
<td>0.102</td>
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<tr>
<td>Min/Min 8</td>
<td>0.132</td>
</tr>
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Insufficient Primary Digester HRT Will Result in Sour Digester, Use Revised Approach
1. Fill Digester 3 with water (30-35% of volume) and heat to at least 90 degrees F using sludge recirculation heating loop.
2. When Digester 3 is ready for operation it will receive digested sludge from Digester 1 until it is full and operating stably.
3. Raw sludge feed to Digester 3 will then start and slowly be increased until both Digesters 1 & 3 are operating in parallel and receiving raw sludge in daily amounts proportional to their volumes.

**Digester 3 Start Keys**

1. Temperature dependent – June/July?
2. Sludge hauling window closes mid-May

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**Final Approach**
Digester Filling Issue

Hydrostatic Pressure Relief Valves

Groundwater
Digester Filling Issue Resolved

Bar Soap (antibacterial)

Groundwater
Digester 3 Operating/Release Digesters 1 & 2 For Work

1. With Digester 3 operating stably raw sludge feed will gradually be increased until it is receiving all raw sludge.
2. Digester 1 can be taken out of service and cleaned to make it available for construction.
3. Digester 3 will be the only operating primary digester and Digester 4 will continue to operate as a secondary digester.

**Theoretical Primary Digester Data**

<table>
<thead>
<tr>
<th></th>
<th>HRT Days</th>
<th>VS Ld lb/d/cf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg</td>
<td>17.6</td>
<td>0.025</td>
</tr>
<tr>
<td>Min/Min</td>
<td>16</td>
<td>0.031</td>
</tr>
</tbody>
</table>
Restart Digester 1 and Digester 2 Phase 1

1. As construction is completed on Digester 2 and then Digester 1 they will be brought back on line following same protocol of first filling with water to 30-35% and heating water to at least 90 degrees F, and then filling with sludge.
2. Transfer digested sludge from Digester 3 to Digesters 1 and 2 until full.

Theoretical Primary Digester Data

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<tr>
<td>Min/Min</td>
<td>16</td>
<td>0.031</td>
</tr>
</tbody>
</table>
Restart Digester 1 and Digester 2 Phase 2

1. Raw sludge feed to Digesters 1 and 2 will then be gradually started so that they can operate as primary digesters in parallel with Digester 3.
2. Digester 4 will continue to operate as a secondary digester.

Digester 3 ready for operation
Release Digester 4 for Cleaning

1. Digester 1 and Digester 2 operated as Primary Digesters
2. Digester 3 operated as Secondary Digester

Spring 2015 Empty Digester 4

- Raw Sludge
Primary Digesters 1 & 2

- Careful, Planned Restarts
  - Preheat with hot water
  - Transfer from active digester
  - Gradual increase in feed
  - Careful monitoring of VA/Alkalinity

- Achieving 50% VSR @ VA/Alk = 0.28
Safety when dealing with open digesters:

- Tape off area/no smoking/no sparking tools or equipment/no vehicles
- Ventilation – contractor needs to use explosion proof fans
- Turn off building intake fans/HVAC units in area
- Ensure doors on all nearby buildings are kept closed at all times
Digester Monitoring/Contingency Considerations

- Daily monitoring of all active digesters for TS/VS, pH, VA/alkalinity ratio, gas production and gas CO2 content (if possible) are critical during these operations. Desire digester pH in range of 6.8-7.5 and VA/alkalinity < 0.4.

- If a digester is showing signs of upset (gradual decrease in pH and/or gradual increase in VA/alkalinity ratio) the raw sludge feed to it will need to be reduced or stopped until it recovers.
Bio-P

Aeration Basins (Aerobic)

Anaerobic & Anoxic Selector Zones

All flow to Activated Sludge Process

April 2015
Other signs of struvite noticed late July 2015
Struvite!
Struvite! 4-5 Months after Bio-P
FeCl Room

In case Bio-P is “upset”
• VFA’s
• Anaerobic selector zone has oxygen
• Other
FeCl Feed Points

DSD-GBT Filtrate Line

RWW Parshall Flume

Gravity Thickener Effluent

MLSS Channel to ML Splitter Box
Sludge GBT’s

WAS GBT’s

Filtrate Wetwell

Digested Sludge GBT
FeCl Feed to DSD GBT

- Started FeCl to filtrate tank & ran mixer on August 7th at about 35 gph on a 9 hour run.
- Observed a decrease of struvite in bottom of tank after 10 days.
- Checked the filtrate pump after 2 weeks and it was clear of stuvite. Checked the other pump today and had the same result. (per the pictures).
- Only feed the FeCl & run the mixer while the DSD-GBT is operating 3x / week for avg 9 hours run
FeCl Feed Rate (to DSD GBT)

- 30 gallons/hour
  - During DSD-GBT operation
BNR Activated Sludge Process Control

- Sludge Wasting
  - Initially – Daily SRT on Low Side – Industry Slug Load Led to Severe Digester Foaming
January 2014
Foam “runs downhill”

The Analysts are shielded from the s\text{\footnotesize t} by the Crest of Ignorance, which keeps s\text{\footnotesize t} from rolling down on them, and ensures that the Consultant remains submerged.

Foam from aeration basins...

...ends up in digesters
Digester foaming correlated with filamentous bacteria outbreak
Digester Foaming
Identifying Problem

MLSS: This sample looked like a mixed liquor from a plant that is operating well. Rotifers and a good mix of protozoa were observed. The level of flagellated protozoa was higher than is probably optimal - this may indicate soluble organics in the system. Most of these flagellates were inside the flocs. Floc structure was good; they were mostly medium to large in size and well-formed. Dispersed bacteria were present at a moderate level.

The dominant filament in the MLSS was tentatively (~85% certainty) identified as Microthrix. This is a thin, Gram-positive filament that often occurs closely associated with the flocs and proliferates in high MCRT (low F:M) conditions. Using the subjective filament abundance scoring system developed by Jenkins et al. (2004), which ranges from 0 (none) to 6 (very excessive), Microthrix was assigned a level of 3 for the wet mount (exam of the Gram stain often results in revising the value upward).

Foam: This sample had many of the same general characteristics as MLSS regarding organisms present and floc structure. However, flocs in the foam tended to be smaller on average (there were still some large flocs present), and many were made diffuse by the presence of a thin, winding filament. This was the same filament - Microthrix - observed in the MLSS. Microthrix was assigned a value of 4.5 in the foam sample - and bear in mind this sample had been diluted 1:10. When most filaments occur at a level of 3, or greater, operational problems are likely. I am quite confident that Microthrix is the filament causing the foaming condition at your facility - examination of the Gram stain will most likely confirm this. There appeared to be a low level of filament type 0041 present in this sample.
Exam of Gram stains has confirmed that Microthrix is the dominant filament in both MLSS (4.5) and Foam (5) (Jenkins ratings in parentheses). Bear in mind the Foam sample was diluted 1:10, so there is an extremely high concentration of Microthrix in the 'raw' foam.

Also observed in the samples was a high amount of Nostocoida limicola II. Nostocoida is a tortuously coiled filament that usually occurs within the flocs (easy to overlook in a wet mount). It is usually Gram-positive to Gram-variable, however it is mostly Gram-negative in these samples. I've assigned abundance values of 4 for MLSS, and 4.5 for the Foam for Nostocoida. Nostocoida can become so tightly coiled that it forms knots in the flocs - knots were observed in these samples. This is one of the few filaments that plants can withstand a fairly high population of and not have significant operational problems. However, at the high levels in these samples, and combined with Microthrix, settling and foaming issues can be expected.

Other filaments were present at lower levels, the highest being type 1851 which occurred at a level of 2 in both samples.

Jeffrey A. MacDonald, MS
MacDonald Environmental Services
3005 East Emily Avenue
Oak Creek, Wisconsin 53154
SHC System (quick, short term)
**SRT** (mcrt, sludge age)  
**Long Term Key**

**Instructions:**
Step 1: Input today's date.
Step 2: Input today's MLSS and RAS concentrations and average final clarifier blanket depth.
Step 3: Input the mixed liquor settlometer test 30 minute settling volume.
Step 4: Input the volume of WAS wasted from the system yesterday (units are gal/day).
Step 5: Input yesterday's plant flow (MGD) and final effluent TSS (mg/L).
Step 6: Check and adjust the Process Inputs as necessary (seasonal or maintenance adjustment - particularly the Target Aerobic SRT).
Step 7: Press "Ctrl" & "w" (lower case w) at the same time and the spreadsheet will update itself (only do this after entering the new values, and only do it once per day).
Step 8: Note the target volume to waste from the activated sludge system. Using this target plus judgment and experience, input the volume to waste into the control system.
Step 9: Check the values you entered and the results shown. If something looks wrong, close the file without saving, then open it again and start at Step 1. If everything looks ok, save the file and then close it.

**Notes:**
- Cells with red bold font in yellow shading are daily inputs (cells B19 through B26).
- If there is no value to report for the blue bold cells, leave the cell blank (press "delete").
- Cells with red bold font in gray shading are process inputs that may change on a seasonal basis, or when basins are out of service.
- Do not leave process input cells blank - must have a value entered in each of these cells.
- Cell with black bold font in aqua shading gives target wasting volume for the day in gal/day.

**Eau Claire WWTP Activated Sludge Wasting Calculator**

**SEE INSTRUCTIONS ABOVE:**

<table>
<thead>
<tr>
<th>Daily Inputs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date:</strong></td>
<td>09/30/15</td>
</tr>
<tr>
<td><strong>MLSS Concentration:</strong></td>
<td>1,920 mg/L</td>
</tr>
<tr>
<td><strong>RAS/WAS Concentration:</strong></td>
<td>3,650 mg/L</td>
</tr>
<tr>
<td><strong>Average Final Clarifier Blanket Depth:</strong></td>
<td>1.2 ft</td>
</tr>
<tr>
<td><strong>30 Minute Settling Volume:</strong></td>
<td>180 mL</td>
</tr>
<tr>
<td><strong>Today's WAS Flow:</strong></td>
<td>180,000 gal/day</td>
</tr>
<tr>
<td><strong>Yesterday's Plant Flow:</strong></td>
<td>5.411 MGD</td>
</tr>
<tr>
<td><strong>Yesterday's Plant Effluent TSS:</strong></td>
<td>3 mg/L</td>
</tr>
</tbody>
</table>

**Process Inputs**

<table>
<thead>
<tr>
<th></th>
<th>Range of Typical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Aerobic SRT:</strong></td>
<td>9.0 6-14 days</td>
</tr>
<tr>
<td><strong>Days Per Week to Waste:</strong></td>
<td>7 5-7</td>
</tr>
<tr>
<td><strong>Selector Zones in Service:</strong></td>
<td>12 2, 4, 6, 8 or 12</td>
</tr>
<tr>
<td><strong>Aeration Basin Passes in Service:</strong></td>
<td>6 1, 2, 3, 4 or 6</td>
</tr>
<tr>
<td><strong>Final Clarifiers in Service:</strong></td>
<td>3 1, 2, or 3</td>
</tr>
<tr>
<td><strong>Tomorrow's Wasting Target:</strong></td>
<td>196,166 gal/day</td>
</tr>
</tbody>
</table>

**System Monitoring**

<table>
<thead>
<tr>
<th></th>
<th>Daily</th>
<th>7 Day R.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aerobic SRT:</strong></td>
<td>9.3</td>
<td>9.6 days</td>
</tr>
<tr>
<td><strong>Total Bioreactor SRT:</strong></td>
<td>12.3 12.7 days</td>
<td></td>
</tr>
<tr>
<td><strong>Total System SRT:</strong></td>
<td>12.7 13.1 days</td>
<td></td>
</tr>
<tr>
<td><strong>Actual MLSS Conc:</strong></td>
<td>1,920 2,129 mg/L</td>
<td></td>
</tr>
<tr>
<td><strong>SVI:</strong></td>
<td>94</td>
<td>92 mL/g</td>
</tr>
</tbody>
</table>
SVI & Influent BOD

SVI: 12/1/14 - 2/28/15

- Single Day Value
- 7-Day Running Average

Inf. CBOD mg/L vs. SVI (mL/g)
February 2015
No one is left behind!
The True Heroes in this Story...

The Eau Claire Wastewater Utility Staff, Including:

- Steve Hayden, Utility Engineer
- Kathy White, Assistant Lab Manager
- Craig Capper, Lab Manager
- Mike Thieste, Lab Tech
- Craig Hendrickson, Plant Superintendent
- Jeff Pippenger, Utility Manager
- Entire Plant O&M Staff
Questions?

Tom Crouse
tcrouse@donohue-associates.com
920-208-0296