The Trials and Tribulations of Commissioning a Large Biosolids Facility

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Presentation Format

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Biosolids General Overview
The Nashville biosolids facility receives sludge from two WRRF’s:

- Central WRRF -- 125 mgd ADF (473 ML/d)
- Whites Creek WRRF – 37.5 mgd ADF (142 ML/d)

The biosolids facility was designed to process the following dry tons of sludge by Year 2021:

- Annual Average – 105 dt/day (95 metric tons/d)
- Maximum Month – 137 dt/day (124 metric tons/d)
- Peak Day – 207 dt/day (188 metric tons/d)

The facility was procured as a “Design—Build--Operate” project.

The facility commissioning process started in January of 2008.

The facility was accepted in March 2010 after passing a 60 day reliability test.
Major Components of the Biosolids Facility

- Anaerobic Digestion
- Recycle Pumping Station
- Drum Dryers
- Centrifuges
- Dissolved Air Flotation Thickeners
- Sludge Transfer Station
The Biosolids Treatment Process
Sludge Transfer Pump Station

• It was the old DAFT building
• Contains four (4) Wemco torque flow centrifugal type pumps each rated at 3,500 gpm (221 l/s)
• There are 2 wet wells with Rotamix type mixing systems
• The solids from two WRRF’s are pumped to this location:
  • Primary sludge
  • Primary scum
  • Waste activated sludge
  • Secondary scum
Dissolved Air Flotation Thickeners (DAFT’s)

- Four (4) DAFT’s
- Ave. Design Solids Loading Rate is 29 lbs./ft\(^2\)/day/DAFT (142 kg/m\(^2\).d)
- Ave. Hydraulic Loading Rate is 1.4 gpm/ft\(^2\)/DAFT (0.95 l/m\(^2\).s)
- Each DAFT 65 ft. (20 m) diameter with 11 ft. (3.3 m) SWD
- The DAFT’s receive:
  - Primary sludge
  - Primary scum
  - Waste activated sludge
  - Secondary scum
- Ave. Thickened Sludge Conc. is 5-6%
Anaerobic Digestion

- Four (4) primary anaerobic digesters
- One (1) secondary digester
- Current Solids Loading Rate
  - 160-220 lbs. V.S./day/1000ft³ (2 563–3 524 g/m³.d)
- Each digester 108 ft. (33m) diameter with 36.5 ft. (11m) SWD
- Ave. Feed Solids Conc. 5–6% T.S.
- Typical gas make-up - 65% methane (650 BTU) [686 kJ]
Sludge Dewatering

- Five (5) solid bowl centrifuges
- Andritz D7LL centrifuges
- Solids Loading Rate 2,600 lbs./hr. (1,179 kg/h)
- Dewatered solids concentration
  - To Dryers – 19 to 23%
  - To Wet Cake – 28–35%
Thermal Drum Dryer Systems

- Two (2) Direct Drying Systems
- Andritz Model DDS80 dryers
- Design evaporation rate per dryer
  - 18,326 lbs./hr. (8,313 kg/hr)
- Final product (pellet) dryness 93-95%
- Final product (pellet) size 1-4 mm
- Gas usage – Natural and digester gas

Note: Plant personnel made SCADA changes for the burner controls that have allowed them to increase digester gas usage from approximately 250,000 ft³/day to 1,300,000 ft³/day.
Sludge Recycle Pump Station

- Three (3) centrifugal type pumps (2 horizontal and 1 dry pit submersible) each rated at 7,000 gpm. (442 l/s)
- Sends flow back to the Central WRRF (2 mgd/day) (7,570 m³/d)
- Flow streams to Pump Station
  - Centrate
  - DAFT subnatant
  - Condenser drains
  - Ventruri fan drains
Biosolids Issues

- Trash pumped to the biosolids facility. (Nashville has combined sewers)
  - Trash results in problems in the DAFT area
  - Trash results in problems in the digesters
  - Trash results in problems in the dryer system
- Initial engineering limitations. (Some of these issues were resolved during commissioning)
- Centrifuge operation (Shutting down and no centrate indication)
- Major Nashville flood in 2010
- Rapid rise issues
- Dystor cover issues
- Gas compressors and refrigerated dryer equipment issues
- Thermal Drum Dryer System issues
- Personnel changes
• The City of Nashville has approximately 224 miles (360 km) of combined sewers that bring in a large amount of debris to the plant.

• The combined sewer system is connected to the Central WRRF.

• The major pumping stations remove the trash from the flow. Originally the solids would go through a grinder and be re-introduce into the flow, however this mode of operation is now changed. Now the solids are removed from the flow.

• Strainpresses were installed at the biosolids facility to remove the debris but they became overwhelmed.
Thickened Sludge Pump

Concrete Pipe Support

Manuf. requires 30” clearance in front of pump
Think about containment around the pump
Valve and Insulation as One
Initial Engineering Limitations

Cover Lifted from Concrete
Initial Design

Static Electricity Shocks walking on the cover

Sludge Withdrawal

Sludge Mixing

Sludge Recirculation

EXISTING DIGESTER
Digester Relief Assembly
Initial Digester Modifications

- Raised Sludge Outlet
- Added Foam Sprays on Liquid Surface

Modified Digester
Centrifuge Commissioning

- During the initial commissioning phase the centrifuges would operate for approximately for 4 hours and then there was a lengthy clean up period.
- It was determined that the centrifuges were being operated at 4,500 lbs./hr (2,041 kg/h) when they were designed for 2,600 lbs./hr. (1,179 kg/h)
- The centrifuges were operated in this mode for several months.
Other Centrifuge Issues

- During commissioning it was realized that there was no way to monitor the centrate leaving the individual centrifuges so optimizing the centrifuges was impossible. Client installed a centrate collection box.

- The centrifuge “Clean-In-Place” water was designed so it went back to the centrifuge feed wet well. This diluted the feed solids so the centrifuges could not make plug (seal). The wet well would have to be drained and refilled with good sludge.
Centrifuge Inclined Screw Conveyor Discharge

Add water connections

Avoid long straight horizontal piping
Nashville 2010 Flood

The Biosolids facility had 2 to 4 feet (0.6 to 1.2 m) of water
**Digester Mixing System**

- Each digester is mixed using a Vaughan Rotamix type system that contains 12 mixing nozzles each 2.5-inches (64 mm) in diameter.
- Each digester utilizes 2 Vaughan chopper pumps each rated at 3,550 gpm (3 l/s) at a TDH of 47 ft (14 m). Both pumps at each digester must be operating at all times.
- **Problems:**
  - Pumps gas lock
  - Pumps are too small for application
  - Trash blockages in nozzles
Rapid Rise Events

Cover supports pulled out of concrete top
Digester Foaming/Rapid Rise
What is the difference between Foam and Rapid Rise?

- Foam is a low specific gravity material that contains mostly bubbles and very little liquid.

- Rapid rise is a phenomena that occurs when there is an expansion of the liquid level within the digester that contains both liquid and bubbles.
Rapid Rise

- Rapid rise events are caused by changes in digester gas holdup rather than foaming in the traditional sense. Gas holdup is the volume of gas present in the digester liquid. If the gas holdup of the digester increases, the total volume of the digester liquid will increase. Likewise, if the gas holdup of the digester decreases, the total volume of the digester will decrease.

- The fundamental principles of rapid volume expansion are related to the physical and biological nature of digester sludge and bubble hydrodynamics, but rapid volume expansion events are primarily caused by operational changes.

\(^a\) Reference: Digester Gas Holdup and Rapid Rise Foam Formation; Tom Chapman, Andy Strehler, Phuong Truong and Steve Krugel.
Rapid Rise Volume Expansion

- The liquid volume expansion in a digester typically raises 10 to 15% on average.
- However, plants have reported a liquid volume expansion as high as 25%.
Typical Causes of Volume Expansion In Digesters

• Digester start-up conditions
• Improper feeding (batch feeding)
• FOG and scum addition
• Sudden temperature changes
• Sudden drop in pressure
• Filamentous organisms from the activated sludge process
• Mixing
  ▪ Stop or reduced mixing
  ▪ Changing mixing intensity
  ▪ Poor mixing

a Reference: Digester Gas Holdup and Rapid Rise Foam Formation; Tom Chapman, Andy Strehler, Phuong Truong and Steve Krugel.
What steps can be done to minimize rapid rise events or damage from rapid rise events?

- Maintain a constant and consistent feed rate to the digesters.
- Maintain consistent digester mixing.
- Maintain a constant digester temperature.
- Design digesters with larger freeboard distances maximum liquid level to top of digester wall.
- Design a submerged cover type digester.
Submerged fixed cover incorporates features of egg-shaped digester

- Enclosed cover eliminates odor and foam release
- Foam & scum suppress circulating sludge
- Gas Withdrawal
- Small gas/liquid interface reduces corrosion
- Maximum volume is used
- Ring beam support to corbels
- Feed/withdrawal separation eliminates short circuiting
- To top circulating sludge
- Cover supported columns
- To heat exchanger
- Heated circ. & feed
Submerged Cover Digester
There are numerous Dystor cover installations located throughout the world that are functioning properly, however the Nashville installation seems to be jinxed.

**Dystor Issues:**

- Side outlet verses top outlet (*Foam from side outlet interfering with gas flow sensor reading*)
- Digester No. 4 – Cover damaged during start-up due to over-pressurization. *(New cover installed)*
- Digester Nos. 4 & 5 – Covers were damaged during the flood when they deflated. *(New covers were installed)*
- Digester Nos. 4 & 5 – New manufacturer cover design that lead to some seams pulling apart. *(New covers were installed)*
- Digester No. 4 – Top outlet hose tie down connection broke during the winter.
Dystor Covers (con’t)

In 2014 the gas outlet hose on Digester No. 4 became blocked with ice causing a gas blockage from the digester thus resulting in blowing the cover.

After numerous damaged Dystor covers between 2008-2014 the client is going with a fixed cover and internal draft tube mixers in a Phase 1 task for process optimization.
In order to construct the new fixed digester cover in Digester 4 extensive scaffolding is required in the digester to support the construction crew assembling the cover.
Gas Compressors and Dryers

- Liquid ring compressors are used to transfer and compress digester gas from the Dystors and send it to the thermal drum dryer systems.
- The liquid ring compressors are driven by constant speed motors so a PRV was added to circulate gas in order to keep the compressor operational when digester gas use is stopped during drum dryer operation.
- The refrigerant dryers continuously shut down due to the loss of refrigerant even though it is a closed system. Once we lose the refrigerant dryers then we cannot use digester gas in the thermal dryer system.
Thermal Drum Dryer Systems

• During commissioning there was a steep learning curve for the operators on how to operate the dryers.

• Initial shaker screen openings were not correct that resulted in filling the recycle bin and shutting down the dryers.

• Erratic digester gas usage due to the gas dryer shutting down.

• Numerous non-planned shutdowns resulting in bringing in a Vac truck to remove solids from equipment.

• Plant water issues would sometime limit process water to the condensers and thus shut down the dryers.
Operator Changes

• Since start-up, the biosolids facility has lost a number of operators and maintenance personnel to other positions within MWS. New personnel were hired to replace lost personnel and to increase staff numbers due to maintenance needs and shift coverage.

• New personnel had to be trained on the various treatment processes at the biosolids facility.

• The new operators are timid about operating the thermal drum drying systems on digester gas. Natural gas is easier to use with the thermal dryer systems. The dryers are the main digester gas utilization systems at biosolids, so additional operator training was required.
Current Process and Optimization Improvements
Current Process Improvements

- Feeding the digesters continuously.
- Metro Water added centrate collection troughs to each centrifuge so we can optimize the centrifuges.
- Metro Water added Digester Mixing Pump amperage readings on SCADA so operators and react quickly if a pump is starting to gas lock.
- Metro Water had made strainpress improvements that improved their performance but still not to a level needed for proper operation.
- Metro Water fixed the digester gas dryer so additional gas can be used in the thermal dryer.
- Installation of FloBeast screening equipment for cleaning sludge streams prior to pumping to the Biosolids facility (Under Construction).
Sludge Screening

EnviroCare FloBeast shown in temporary location screening primary sludge

Removing a truck load of solids per day
Current Improvements Under DB Construction

- The membrane cover on Digester 4 is being converted to a fixed cover.
- Each primary digester is being equipped with five (5) internal draft tube mixers.
- New external standpipes are being install at each primary digester.
- New positive displacement transfer pumps.
- The Rotamix systems and pumps are being removed in Digesters 1-3. The Rotamix system will be remain in Digester 4 since it can serve as a primary or secondary digester and the Rotamix system is needed when the liquid level is below the intakes to the internal mixers.
Proposed Internal Mixers

New and Larger Overflow

New Internal Draft Tube Mixers
Drawing of the Proposed External Standpipe

- Normal Flow
- Rapid Rise Flow

To Sludge Recycle PS

To Sludge Transfer Pumps
Future Optimization Projects
Future Biosolids Optimization

BC completed reports in 2015 and 2017 outlining optimization recommendations for the biosolids facilities that will further improve process performance and digester gas utilization.

Recommendations included:

- Provide additional digester gas storage.
- Install smaller waste gas flare.
- Add VFD’s to the dryer Induced Draft Fans and remove the inlet dampers.
- Look at Pellet Storage Area to cool down final product during heating issues.
- Thermal drum dryer equipment and control improvements. (Off-spec silo, additional access walkways and other improvements)
Summary
Summary

- Even with all of the different issues that were encountered since commissioning the Biosolids facilities has been processing an average of 111 dry tons/day (101 dry metric tons/d) of Biosolids.
- The new internal draft tube mixers will help reduce rapid rise events.
- The new external standpipe design will reduce the chances of raising the fixed cover during a rapid rise event.
- Other future improvements will improve process performance.
- Keeping the O&M staff well trained so they can notice issues and have the knowledge to correct/troubleshoot any issues before a major problem occurs is also key to successful operation.
Questions