Northeast Residuals and Biosolids Conference 2014

Full-Scale Case Study of Rapid Volume Expansion of Digester Contents

October | 2014
Acknowledgements

• Tom Chapman – Brown and Caldwell- Tucson, AZ
• Steve Krugel – Brown and Caldwell- Seattle, WA
Agenda

• What are we talking about when we say rapid volume expansion? Is it foaming or something else?
• What factors can influent events?
• Example events at the Brightwater WWWTP in Woodinville, WA.
• Design modifications to manage events.
• Take homes
What is Foam?

- Gas bubbles entrapped in the liquid matrix
- Surface tension and capillary forces stabilize foam bubbles
- Foaming increases when the surface tension of the liquid is reduced (increased bubble stability)
- Foaming agents (surfactants) increase foam formation
- Foam bubbles collapse when liquid drains by gravity
Foam in Digester Reduces Available Headspace
Why is digester volume expansion not foaming?

- Digester volume expansion is caused by changes in digester gas holdup
- In some cases, an apparent foaming event is actually caused by expansion of the digester contents
- Rapid volume expansion can present a significant risk to digester and operator safety
During normal digester operations gas generation and evolution to the headspace are at equilibrium.
Principals of digester gas hold-up and volume expansion

Typical Digester Operation: Gas production and conveyance to headspace is at steady state.

When conveyance and production are out of balance.
Examples of gas hold up in liquids
Bubble Hydrodynamics – The Science of Gas Holdup

- Sludge Characteristics that impact/result in slow bubble rise rates
  - **Size**: Small bubbles rise slower than large ones
  - **Viscosity**: Digester sludge is viscous, behaves as a viscoplastic, reduced viscosity with increase shear stress (mixing)
  - **Surface tension**: Surfactants present in digesters reduce surface tension
  - **Pressure**: Tall digesters have higher pressures near the bottom
  - **Particles**: Grit and solids in the digester will impact bubble size
Improved digester design, increased process efficiency has made this an issue
WAS and Filaments

• Foam trapping allows accumulation of Nocardioforms

• Hydrophobic surface causes attachment to air bubbles

(Source: Parker et al, WER, Vol 86, No 6, 2014)

Figure 10—Step BNR flowsheet for nitrogen removal requires introduction of seven baffles in a four-pass tank.
Digester Operation Influences Gas Holdup

• Changes in gas holdup impact the volume of digester contents

• Common causes of volume expansion are related to digester operation:
  • Digester feed rates
  • Digester mixing intensity
  • Power outages
  • Scum addition
  • And more...

• It is unlikely we can eliminate or prevent all volume expansion events
Example - Sudden Changes in Mixing can Cause Volume Expansion

• Several documented cases of volume expansion following a sudden change in mixing

• Changes in mixing direction can cause a sudden shift in gas holdup resulting in a dramatic change in liquid level
Brightwater Digesters Info

- Modern digester design
- Similar to an egg shaped digester but lower construction cost (Modified Silo)
  - 3 digesters, 1.25 Mgal each
  - 1 storage tank, 790kgal
  - Diameter 59 ft
  - Digester SWD 65 ft
Brightwater WWTP digestion process
6-Hour Power Outage Statistics

• Density change due to gas holdup
  • Start density near water: SG = 0.92
  • End density lower than water: SG = 0.77

• Volume transferred:
  • 140,000 gal, 11% of digester active volume transferred to Blending Storage tank
  • 400-500 gpm transfer rate
New Research: Laboratory scale supports the full scale observations

Digester Modifications During Commissioning

- Verified existing overflow capacity was sufficient – Yes, it was!
- VFD operation of digester mixers - slow changes in mixer speed and direction
- Radar level monitoring – accurate surface/liquid level monitoring
Surface Level measurement
Verifying Radar Accuracy

- Verified with tank level measured in the sample hatches
- Accuracy measured within 1%
Radar shows the true digester level

~10 ft = 204 kgal or about 26% of the tank volume
Take Home Message

• DESIGNERS:
  • Consider rapid volume expansion in future digester designs

• OPERATORS:
  • Be aware of rapid volume expansion during operations and maintenance activities

• I would be interested in hearing about experiences from your plants