The Foam Wars

A Case History of Marquette's Fight Against Digester Foaming

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It was the summer of 2009, another quiet weekend evening in a small northern town. Folks had settled into their homes, safe in the surrounds of family and friends. Teens were out driving around, hanging out at burger joints and movie theaters. Parents were putting their young ones to bed. Young couples were strolling along the shore of Lake Superior, enjoying the starlit sky.

Then it happened. Was there a flash across the sky? Folks weren't sure. But suddenly, a thick, dark ooze started to slowly make its way across the landscape. Were there victims? There weren't any witnesses, nor remains to identify. So no one could say for sure, but one thing was certain, a new monster had come to town.

No, it wasn't the Blob, nor was Steve McQueen (or his ghost) present to combat it. The new monster in town was anaerobic digester foam, and it was up to the City of Marquette's wastewater treatment plant staff to take it down, without the help of McQueen and his teenage buddies. This is their story…

Marquette's WWTP

The City of Marquette operates a 3.85 mgd wastewater treatment plant that was upgraded in 2007-2008. Gone were rotating biological contactors (RBCs), replaced with a new activated sludge system designed for nitrification and enhanced biological phosphorus removal (EPBR or Bio-P). Other improvements included new secondary clarifiers, upgrades to the anaerobic digesters, a combination gravity belt thickener/belt filter press, and various other improvements.

The upgraded facilities officially came on line in the fall of 2008, with the Bio-P selector zones following in April 2009. Upon startup, the plant performed quite well, quickly achieving full nitrification and producing a very high quality effluent. In April, with startup of the Bio-P selector zones, the plant quickly transitioned from a chemical phosphorus removal plant to one rarely having to use ferric chloride, and then mainly for chemical polishing or side-stream treatment.

The Marquette anaerobic digestion process is comprised of

two primary digesters, each of 350,000 gallons volume, and a single secondary digester with a volume of 400,000 gallons. The primary digesters were upgraded with new jet nozzle pumped mixing systems, new digester heating equipment, and new gas safety equipment.

The primary digesters are fed a mix of primary sludge, thickened to 4-6% TS in the primary clarifiers, and waste activated sludge, also thickened to 4-6% TS on the gravity belt thickener and then stored in a TWAS wetwell. Both the thickened primary sludge and TWAS are pumped at a low, continuous rate to the primary digesters. Since startup of the new facilities raw sludge loadings have averaged 12,000-15,000 gallons per day and 3,000-4,000 lbs VS/day.

The Foam Wars begin

Historically, as an RBC plant, the Marquette WWTP never had experienced digester foaming episodes. And through the upgraded plant's initial startup this continued to be the case. And then the foaming overflow episode of the summer of 2009 occurred, and from that point on plant staff became engaged in an ongoing struggle to understand why foaming was occurring, and how to control or prevent it. Foaming became so severe that by the winter of 2009 the digester gas collection piping had plugged and plant staff were forced to purchase natural gas for digester and building heating (when normally biogas would have been sufficient for these purposes).

Initial suspected causes were quickly ruled out:

- The activated sludge system had not experienced significant foaming episodes due to Microthrix or Nocardia type organisms.
- Primary digester overloading was not occurring, as noted by:
  - Average digester detention time ranged from 47-55 days.
  - Average digester VS loadings ranged from 0.037-0.045 lb VS/cf/day.
  - VA/alkalinity measurements falling in the range of 0.11-0.23.
  - Temperatures maintained in the range of 90-100 degrees F.

As investigations continued, a few factors were identified as potentially contributing, if not causing the foam to propagate. These factors are discussed below.

Digester mixing – too much of a good thing?

It is often accepted that continuous mixing of digesters leads to better and more stable performance, due to promotion of uniform temperature profiles in the digesters and avoidance of localized hot spots of high VS loading – potentially creating localized overloading conditions.

The Marquette staff had operated their pumped nozzle jet mixing system continuously from startup, but as the foaming problems developed and worsened, staff began to question this practice and began operating the mixing systems intermittently. It seemed like, while foaming continued, it wasn't as bad with such intermittent operation.

It is generally becoming accepted that these jet mixing systems provide excess energy and shear at the nozzle outlets, and that such systems should be operated intermittently or with VFDs so the pumping rates can be reduced much of the time. Marquette staff tried throttling the pump discharge valves to reduce the pumping rate, but results were inconclusive (i.e., no noticeable change in foaming), and as a result went back to intermittent operation.

Digester temperature – range and stability?

With regard to anaerobic digester temperatures, there is a rule of thumb that one shouldn't change the temperature of the digester by more than 1 degree F per day. In other words, not only is it important to stay in the mesophilic temperature range (90-100 degrees F), but it is also important to maintain relatively stable temperatures in this range, to avoid upsetting the microbial population performing digestion.

During the first year and a half after startup, the Marquette digesters were effectively maintained in the mesophilic temperature range. However, upon inspection of daily readings it was observed the temperature of the primary digesters at times changed by as much as 3-5 degrees F in a 24-hour period. It was discovered a valve controlling the hot water bath temperature to the sludge heat exchangers was not operating properly, resulting in these temperature swings. This problem was corrected in May 2010, and primary digester temperatures have been much more stable (i.e., no more than 1 degree F change per day) since. Unfortunately, resolution of this problem did not lead to elimination of digester foaming, but may have helped make it less severe.

Summer 2009 – the beginning of the Foam Wars.

Testing of foam suppression nozzle with bottom flat plate discharge at WAS storage tank. Note evidence of brown scummy foam at tank surface.

WAS storage – a breeding ground?

As part of the upgrade project, the plant's original secondary clarifier was converted to an aerated WAS storage tank. This tank allows staff to waste from the activated sludge system continuously, but thicken intermittently such as after a long weekend. In observing the surface of this tank, which has a submerged withdrawal, it is often covered with foam even though the activated sludge system itself is not experiencing foaming problems. It may be that the surface detention time in this tank is long enough to allow foam-causing filaments, which usually require long sludge ages, to propagate. The question then is, does the WAS storage tank grow these organisms and seed them into the digester?

In early 2012 plant staff experimented with bypassing this tank and wasting directly to the GBT. Results were inconclusive with regard to this bypassing and whether it had any impact on digester foaming. As a result plant staff have resumed using the WAS storage tank.

"Does the WAS storage tank grow these organisms and seed them into the digester?"

When all else fails – deal with it

Frustrated in trying to understand and eliminate the cause of their digester foaming, the plant staff decided to see if they could knock the foam down to protect the digester gas collection piping. To do this, they installed nozzles located above the level of the foam in each digester, and connected these nozzles to the jet mixing pump discharge lines. The results showed the foam was able to be knocked back down into the liquid, even with the jet mixing systems operating continuously.

As a result plant staff installed smaller, dedicated foam suppression pumps which were hard piped to the foam suppression nozzles. These pumps began operation in the summer of 2011 and have effectively controlled foam to manageable levels for over a year now.

Where we go from here

WERF has an ongoing research study focused on digester foaming causes and control, being led by Krishna Pagilla out of Illinois Institute of Technology. As part of this study the project team is performing case studies of several WWTPs with significant digester foaming problems. Marquette is one of the plants participating, and has been implementing suggested process and operational changes suggested by the research team. This research effort is expected to continue through the rest of 2012, and it is hoped that the end product will provide guidance information to help Marquette and other plants fight their foam wars.

Meanwhile back in Marquette, it's another peaceful, starlight summer evening. And plant staff are relaxing much more easily, enjoying a show of Northern Lights with the comforting knowledge that their foam suppression system is keeping things from oozing in the night. CS