Case Study of Anaerobic Digester Foaming in Egg Shaped Digesters

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Abstract
Egg-shaped anaerobic digester foaming has been a consistent problem for the Oceanside Water Pollution Control Plant (OSP) since start-up. Seasonal intermittent foaming events have been correlated to the presence of nocardioforms. This paper presents a case study of anaerobic digester (AD) foam detection and control strategies that will help better comprehend this common issue. Given the unique gas piping coupled with an ESD configuration, it is difficult to conclude if mixing may or may not be a contributory factor of AD foaming at OSP. Modifications to both mixing configuration as well as the mixing frequency have been evaluated in this full-scale study. This paper will also discuss methods implemented to detect and document foaming episodes as well as estimating sludge foam potential. Initial data indicate that foaming events were shorter and fewer in the digester mixed intermittently than the one mixed continuously.

Keywords
Egg-shaped digesters; foaming; mixing; foam collapse.

INTRODUCTION

Egg shaped digesters (ESD) are being used in anaerobic digestion (AD) due to several perceived advantages. Foaming potential may be lowered in ESDs because of the higher gas flux in a smaller surface area (Moen, 2003). ESDs have a very limited surface area above the bulk phase of the digester reducing the scum and foam accumulation potential while poor mixing and grit accumulation has been observed in cylindrical digesters creating dead spaces and short circuiting of sludge. From a mechanistic point of view, there is no explanation as to why ESD may be better with respect to prevention of foam formation and persistence (Tchobanoglous et al., 2003). Mixing, though not a direct cause of foaming has been popularly attributed to contribute to foaming in several ways. The City of San Francisco's Oceanside Plant (OSP) has 4 ESDs and has reduced the mixing in the digesters by changing to lower-to-top ring mixing configuration. The mixing provides about 6 turn-overs per day. Given the unique gas piping coupled with an ESD configuration and occurrence of *Gordonia* (*Nocardia*) *amarae* in the activated sludge process, it is difficult to conclude if mixing may or may not be a contributory factor of AD foaming at OSP, especially in the rapid expansion foam events, leading to this full-scale study, investigating foaming strategies in ESDs.

Background

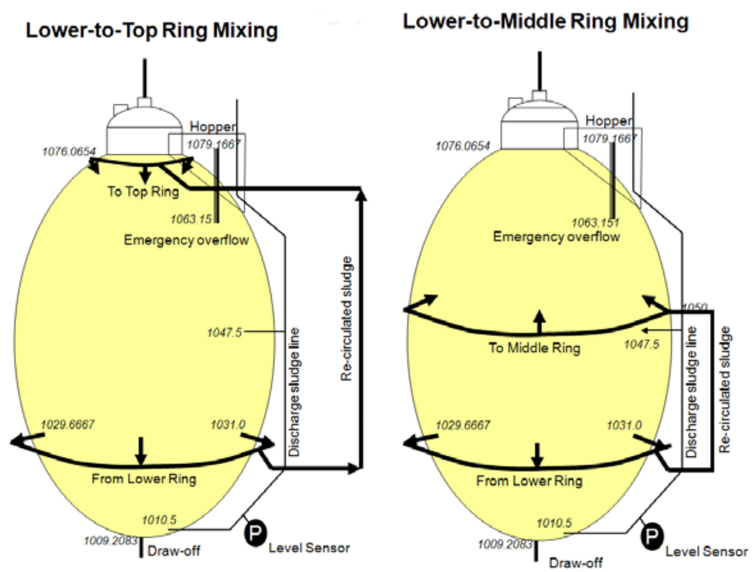
Digester foaming has been a consistent problem for OSP; mostly determined to be due to nocardioforms. Many anaerobic digester foaming incidents have been attributed to the presence of *Gordona amarae (G. amarae)* in WAS feed to the digester (Pagilla et al., 1996). OSP has experienced both conventional foaming events as well as rapid foam collapse. The rapid collapse foaming episodes could be an offshoot of the gas piping configuration. Each of the digesters have an emergency overflow pipe equipped with a P-trap, which prevents loss of seal in the digesters but rapid foam collapse still occurs. Effect of mixing on AD foaming in ESD is investigated at full scale as given in Table 1.

Table 1. Full Scale Mixing Strategy

		Mixing Frequency		(% of the time)
		Dig. 1	**Dig. 2**	**Dig. 4**
Since Plant Start-up		100%	100%	100%
Phase 1	Jan-Apr 2012	100%	75%	50%
Phase 2	May-Sept 2012	100%	50%	25%
Phase 3	Oct-Dec 2012	25%	25%	0%

Digester Mixing Modes

The suction/discharge strategy of the centrifugal mix pump can be configured by two series of parallel valves at the base of the digester (Figure 1). Sludge can be discharged from any of the following: the top ring, the middle ring, the lower ring, and the bottom discharge line. Sludge can also be drawn from any of those lines with the exception of the top ring, due to its elevation in the digester. Flow through the four recirculation rings surrounding the digesters can be varied giving the operator significant control over mixing. The default mixing mode at the OSP used to be lower-to-top ring mixing with continuously operating centrifugal mix pumps until it was changed to lower-to-middle in early 2012 in an attempt to decrease foaming event frequency. Beating down of the foam is induced by using the top mix ring whenever foam reaches the gas line. The control strategy can be altered to reduce mixing frequency and to change pump suction/discharge.



A. Anti-Foaming **B. Normal Mixing**

Figure 1. Different Digester Mixing Modes

Causes of Foaming

Various factors that are potentially indicative of foaming events have been identified as significant changes in gas production, gas head-space pressure, sludge level, and sludge temperature over the course of a single day. The presence of nocardioforms in the WAS from the secondary clarifiers has also been considered. Table 2 below lists the foam triggers and the observed threshold values of each.

Table 2. List of Identified FoamTriggers

Trigger	Cut-off Value
Nocardioform count	$>10^6$/g TSS
Gas flow rate differential	$\Delta Q>100$ cfm
Pressure differential	$\Delta P>10$

Foaming periods are correctly captured in an approximate sense by the frequency of the triggers, but periods of high frequency do not necessarily indicate a foaming period. This technique is therefore useful for identifying past periods of foaming without anecdotal corroboration. On the other hand, it does correlate foaming events with significant changes in the variable in question namely, gas production, gas pressure, sludge level, and sludge temperature. The primary cause of foaming is nocardioforms in the feed sludge.

Figure 2 below shows the levels of nocardioform filaments during the period 2010-2011, when digesters were mixed continuously from lower to top mixing rings. The highest numbers correspond to foaming periods as indicated within the dashed lines. By and large, presence of excessive foam causing filaments have more often caused AD foaming than not.

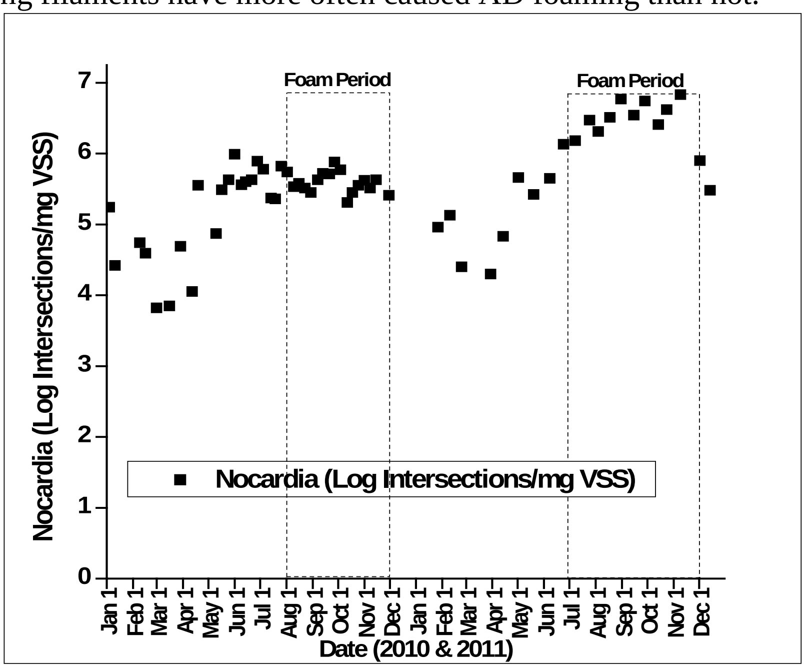


Figure 2. Nocardioform Population for 2010 and 2011

Presence/Absence of Foam

Presence/absence of foam during the mixing trials has been detected using the foam separator trap-drain temperature differences. Figure 3 below represents data from the data-logger systems. Temperature greater than 72 °F indicates that foam / sludge is reaching the digester's gas line.

From the graph below, digester 4 does experience intermittent foaming but events are relatively fewer and shorter than in digester 1, which is mixed continuously. Whenever operators observe that solids are being carried over into the gas line, they also change the mixing mode from bottom to middle to bottom to top (as described earlier) in order to beat down the foam using the top nozzles. This successful procedure was implemented in summer 2012 and more data will be available during the expected foaming season late in 2012.

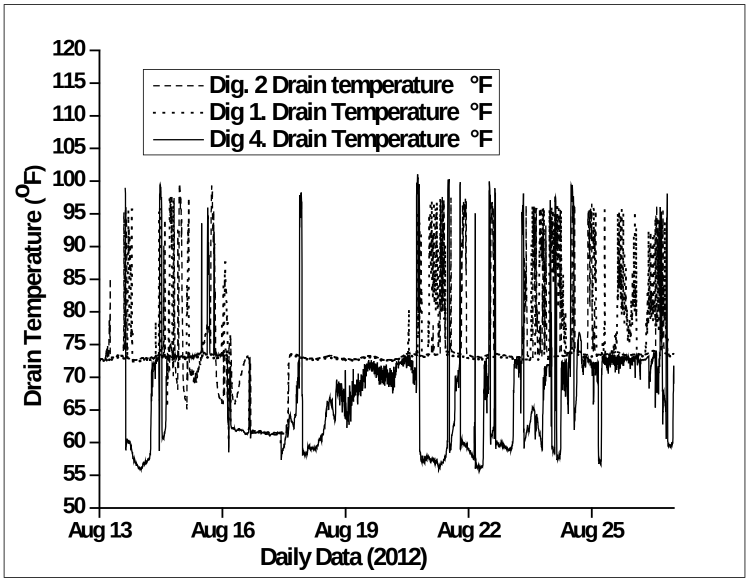


Figure 3. Presence/Absence of Foam: Temperature greater than 72 °F indicates that foam / sludge is reaching the digesters gas line.

Summary

Thus far, the digester mixed intermittently has experienced lesser and shorter events than the one mixed continuously. More data is currently being collected. Digester foam in OSP has been compared to cause a "soda bottle/champagne bottle" effect of dissolved flotation and dissolution of digester gas due to potential pressure variations. OSP has determined several ways to sense and monitor foam episodes, which are working effectively. The full manuscript will help understand the potential foam causing factors and to develop strategies that will continue to minimize/prevent foaming from occurring in ESDs. Lab testing data not limited to foam potential and surface tension will also be included in the final manuscript.

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