SCUM – A LIABILITY OR AN ASSET?

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ABSTRACT

Until recently, the 166 MGD City of Fort Worth Village Creek Water Reclamation Facility pumped scum from its primary and secondary clarifiers, gravity thickeners and filter backwash clarifier to either of two large concrete tanks. The two tanks were operated in parallel, using one tank at a given time. The scum was then concentrated by removing subnatant from the tank and allowing the scum, along with entrained solids, to accumulate at the surface. Once concentrated, the scum was pumped out using an outside contract company and hauled off to a landfill for disposal. Removal of the scum cost was around $400,000 per year, and the scum tanks were a significant source of odor in the plant.

In its continued effort towards efficiency and energy conservation, the City decided to install a scum screening system to remove plastics and other trash solids from the scum. The two scum tanks were converted from parallel to series operation, with the first tank acting as a holding tank and preliminary concentrator for unscreened scum. The solids-laden scum is pumped from the first tank through a scum screen to the second tank, which further concentrates the screened scum. Screenings from the screen are bagged and sent to the landfill with the screenings from the plant’s headworks. Two screens were considered and evaluated that are typically used to screen primary sludge. Huber Strainpress® was the selected screen for the project.

The screened scum is pumped to the plant’s existing co-digestion facility where it mixes with high-strength waste and subsequently goes to anaerobic digestion to boost biogas generation in the digesters; thereby making the scum an asset. Biogas fuels the plant’s combined heat and power system, which fulfills the majority of the plant’s energy demand. Although the impact on energy generation is nominal compared to the contribution from the high-strength waste, the project is anticipated to have about a two-year payback due just to the elimination of off-site scum disposal costs. This project is an outstanding example of how one facility has turned a liability into an asset through the innovative application of technology.

KEYWORDS

Wastewater treatment, scum, screening, anaerobic digestion, biogas, energy

INTRODUCTION

The Fort Worth Village Creek Water Reclamation Facility (VCWRF) is a 166 MGD conventional treatment plant with primary clarification, single-stage activated sludge, tertiary filtration and effluent chlorination/dechlorination. The plant thickens its primary sludge and
secondary sludge before stabilization in 14 mesophilic fixed-cover anaerobic digesters and subsequent dewatering on belt filter presses. Two 5 MW gas turbine / generator sets were installed in 2001 to burn digester biogas and landfill gas and satisfy roughly half of the plant’s electrical demand.

Scum from the primary clarifiers, final clarifiers, gravity thickeners, and the filter backwash clarifier is pumped to concrete scum tanks, where it originally was concentrated and pumped into two natural gas-fired incinerators. This paper describes the evolution of the plant’s scum management from energy consumption to energy production.

In recent years, the City has completed many energy savings projects at VCWRF in multiple phases, utilizing performance based contracting services. In performance contracting, an energy service or energy savings company (ESCO) implements cost-saving improvements and the City takes out a loan to pay the ESCO. The City then repays the loan out of its annual savings, which are guaranteed by the ESCO. The projects were completed as Facility Improvement Measures (FIMs) to reduce energy demand and generate additional energy at the plant. The FIMs that relate to the subject of this paper include:

- FIM 2: Install heat recovery system for steam generation
- FIM 3a: Install high-strength waste (“HSW”) co-digestion system
- FIM 3b: Install linear motion mixers in six digesters

A key component of the energy savings project was the addition of a duct burner and a heat recovery steam generator to generate high-pressure steam to drive two steam turbine / blower sets. The plant’s existing biogas and landfill gas flow rates were inadequate to feed the gas turbine and the duct burner at the necessary rate; therefore, the City upgraded six of its digesters and constructed a dedicated system to add HSW and plant scum to meet the plant’s energy needs. The following discussion focuses on the incorporation of the scum stream into the co-digestion system.

**PROJECT DEVELOPMENT**

The plant’s gas turbines use biogas from the plant’s anaerobic digesters and landfill gas piped from the nearby landfill to supply a significant amount of the plant’s electrical demand and also provide hot water for digester heat exchangers. Given the ≈30% electrical generation efficiency of the turbines, and the relatively minor digester heating demand, the attention was turned towards the waste heat in the turbine exhaust stream.

**High Pressure Steam Generation**

The exhaust from the gas turbine represents a significant energy loss from the system; the waste heat could be used to generate high-pressure steam which, in turn, could be used to drive the two steam turbine / blower sets. The addition of a biogas burner to the turbine exhaust duct and installation of a heat recovery steam generator (HRSG) downstream of the burner would allow the use of both blower sets. Figure 1 is a simplified process flow diagram for the resulting energy recovery system. All items were operational at the conclusion of the energy savings project with the exception of incorporating scum into the HSW stream. Additional details of the various projects have been presented previously (Ripley, et al, 2014).
Identification of HSW and Scum Utilization

At the time the energy savings project was being developed, the VCWRF staff identified potential HSW suppliers, but also wanted to divert the scum stream from its natural gas-fired grease incinerators to the co-digestion facility. Sending scum to co-digestion would save even more energy by eliminating the natural gas purchases and increase the biogas production. In April of 2010, the project gained importance when one of the grease incinerators experienced a serious fire that destroyed both incinerators and gutted the incinerator building. The cost to rebuild one of the incinerators was estimated to be nearly $1,000,000, so the City abandoned them and switched its grease handling strategy.

After the incinerator fire, the plant pumped scum to one or the other of the two scum tanks. Each tank is equipped with an underflow baffle that allows the scum to concentrate on the surface, while subnatant passes through the tanks and over a weir to the plant drain. The plant let the odorous mixture of partially emulsified scum, plastics, paper, and other trash solids concentrate and accumulate to a depth of 8-10 feet. The plant then redirected the incoming scum to the other tank and hired an outside contractor to pump out the scum and solids mixture, and haul it to a landfill. The pumping operation was an operational headache and a major source of odors, with an annual cost that climbed to $400,000 per year.

The initial energy savings project included an installation of a chopper pump and transfer pipeline from the scum tanks to the HSW blend tank in the new co-digestion facility. Unfortunately, the project did not include any method to remove the trash solids from the scum, so they would have become a problem in the digesters and would have been a visible nuisance in
the plant’s dewatered biosolids which are land applied. Therefore, the City continued to accumulate and pump out the tanks rather than using the transfer pump and pipeline.

**DESIGN CONCEPT**

This paper’s project is a continuation of City’s commitment to energy savings projects and was developed to accomplish several goals:

- Eliminate the process of accumulating 8-10 feet of scum and solids, with its significant odor generation,
- Eliminate the cost to pump out the scum and transport it to the landfill,
- Keep the visible scum solids out of the finished biosolids,
- Avoid going back to incineration, with its natural gas demand, and
- Generate some additional biogas in the co-digestion system.

This project also would generate a significant sustainability benefit by eliminating the disposal of the scum in a landfill. Even though much of the methane produced by the scum in the landfill might be captured and burned, a large fraction of the methane still would escape from the landfill. The greenhouse effect from methane is many more times detrimental than the effect of the carbon dioxide that would be produced from combustion of the resulting digester biogas in the treatment plant.

The proposed design concept entailed adding a scum screening system to remove plastics and other trash solids from the scum and converting the scum tanks from parallel to series operation. The first scum tank would act as a holding tank and preliminary concentrator for unscreened scum. The solids-laden scum would be pumped from the first tank through a scum screen and into the second tank which further concentrates the screened scum. Then, the screened scum would be pumped to the co-digestion facility using the chopper pump and transfer pipeline as originally intended in the energy savings project.

**DESIGN IMPLEMENTATION**

Design considerations for the scum screening system included how to collect scum within the tanks, equipment selection, redundancy, flexibility, flushing, and odor control. The following discussion expands on each of these. Figure 2 illustrates the process flow diagram of the system.

**Scum Collection**

The decision was made to keep the collection system simple. To collect the concentrated scum in each tank, scum troughs were utilized at the downstream end of the tanks. Each tank contains a single fiberglass reinforced plastic trough equipped with an adjustable weir. The troughs were placed one inch below the subnatant overflow weir of the tank and rely on the hydraulic drawdown over the weir to move scum into the trough. Other mechanical and hydraulic methods for moving scum into the troughs were considered, but would either require major improvements to the tank structure and/or result in equipment that would be hard to access and maintain. Additionally, each tank is equipped with an existing submersible mixer previously used to mix the contents prior to pumping them down for off-site for disposal. If needed, the mixers could be used to break up the scum to facilitate movement into the troughs.
Equipment Selection

The equipment selected to screen the scum is typically used for screening primary sludge. Two manufacturers were considered for the scum screen, Hydro International and Huber Strainpress®. The screening technology separates, compacts, and dewater coarse material from the process stream. The screen utilizes perforated mesh screens around a two-part Archimedean screw. Within the screen, the removed screenings are pressed against a retention cone by a pneumatic ram system to form a continuous plug to prevent the free fluids from passing. At the other end of the cone, screenings discharged beneath the screen. The screw operates automatically based on differential pressure across the screen. Figure 3 illustrates the basic configuration of the screen. A screen perforation of 6 mm (~ 0.25 inch) was selected to capture the size of inert material anticipated in the scum while not collecting the material (fats, oils, grease, etc.) that is intended to be sent to co-digestion. The design throughput of the screen was 400 gpm with a maximum screenings volume of 35-ft³/hr.
Recessed impeller centrifugal pumps were selected for the scum screen feed pumps due to their non-clog qualities and ability to pass solids. Due to space constraints, vertical pumps were chosen. Manufacturers considered for the scum screen feed pumps were Wemco and Hayward Gordon. Wemco was the selected pump manufacturer. The screened scum transfer pump used the existing vertical Vaughn chopper pump installed during the energy savings project.

Redundancy

Because of the large storage volume available to hold scum in the existing tanks and the fact that scum management is not a critical process for the VCWRF, the system was not designed for full redundancy. Two scum screen feed pumps were provided, however, only one scum screen was provided with space and connections for a future scum screen. In the event the scum screen requires maintenance, scum will be allowed to concentrate in the east scum tank until the screen is back in operation. If the scum screen is down for an extended period, an outside contractor can be hired on a temporary basis to pump down the tank and dispose of the scum off-site as done in past recent years. Two 1/2 cubic-yard hoppers were provided to collect screenings.

Flexibility

Scum is intermittently pumped to the scum tanks from sixteen pump stations throughout the plant. The design made no attempt to quantify the amount of scum the plant generates or determine the varying flows that would enter the east scum tank. As such, flexibility of the system was incorporated into the design to accommodate both manual and automatic operation. In automatic mode of operation, the scum screen feed pumps operate in lead/lag with an adjustable duration between runs and adjustable run times. Similarly, the screened scum transfer pump controls were modified to incorporate adjustable duration between runs and run time.
Flushing

Due to the susceptibility of scum to cake the sidewalls of pipes and equipment, the ability to flush the system was incorporated into the design in two ways. First, flushing connections on blind flanges were strategically placed throughout the piping system. Secondly, an 80-gallon water heater was provided to flush the system after each run of the scum screen feed pumps for an adjustable period of time. The hot water connection was incorporated on the check valves located just downstream of the scum screen feed pumps.

Odor Control

Because the equipment is located inside a building that is also occupied at times for various plant-wide carpentry activities, odors were of concern. The added benefit of the selected screening technology is that the unit is completely enclosed. In addition, a screenings bagging unit was provided that connects to the discharge side of the screen and drapes down to the screenings hopper. As a result, the screenings are never exposed to open air, also minimizing human exposure.

CONSTRUCTION

In order to expedite construction and quickly realize the financial benefits of the project, the City opted to issue a change order to an on-going construction contract; VCWRF Deep Bed Media Filters rehabilitation. The ongoing $16.3M filter rehabilitation project is adjacent to the scum screen project site and is also being managed by the scum screen project’s personnel. By using a major contractor already on-site, along with the same City/Consultant team on both the filter rehab and scum screen project, the cost for bidding the project was eliminated and costs for overall construction administration were minimized.

To further fast track the project and accommodate schedule constraints of the filter rehabilitation project, the City/Consultant team pre-negotiated major equipment pricing, selected equipment and placed orders while negotiating the change order with the on-site contractor. The negotiated change order to construct the scum screen project came out to be $459,100, very close to the estimated opinion of probable construction costs. The project was constructed at the negotiated price with no additional increases to date.

As discussed in the preceding sections, the two scum tanks were converted from parallel to series operation. The first (east) scum tank contains unscreened scum while the second (west) scum tank contains screened scum. Phasing of the construction required work in the east scum tank to be completed first. Once complete, all unscreened scum was directed to the east tank and work in the west tank began. The idea being that once pumped down, cleaned, and modified, the west scum tank would only receive screened scum. This construction sequence avoided the need to pump down the west tank a second time and dispose of unscreened scum off-site at a significant cost to the City.

RESULTS AND CONCLUSIONS

The scum screen system has allowed the VCWRF staff to effectively manage and beneficially use generated scum. What once was a liability is now an asset! The previous operation resulted in a source of high odors at the plant and around $400,000 per year in disposal costs to the City. The current operation allows a minimal scum depth to be held in the scum tanks, thus minimizing odors, and albeit small, increases the capacity to generate energy through co-digestion. Figure 4 illustrates before and after photographs of the scum tanks.

Figure 4 – Before and After Scum Tank Photographs

Currently, the scum system is being operated in manual mode about 20 minutes each day resulting in a scum depth in the tanks of 1-inch to 3-inches. There has been some bridging of scum that limits the amount of scum carry-over into the collection troughs to less than desirable. To break up the scum layer and facilitate movement of the scum into the troughs, the tank mixers are briefly ran (< 10 sec.) just prior to starting either the scum feed pump or screened scum transfer pump.

In the near future, the scum screening operation will switch to automatic mode and run on a more frequent basis. The anticipated operational frequency and duration is once every 1 to 4 hours at 10 to 15 minutes per run. Running more frequently will minimize the scum depth in the east scum tank and ideally avoid the need to “bump” the mixer prior to each run. The transfer of screened scum to the co-digestion mix tank will continue to operate in a manual mode. The transfer of scum is dependent on level in the co-digestion mix tank and is coordinated with HSW deliveries.

The screenings produced are minimal and average just under 1/2 cubic-yard per day. Given the limited use of a screening technology typically used for primary sludge in a scum application, it was unknown during design how much “good” scum would be removed along with the screenings. The screenings are fairly typical in make-up and consistency as would be expected in primary sludge screenings. There appears to be very little fats, oils, grease, etc. being removed with the screenings. The building where the scum screen is housed also has no noticeable
increase in odors inside the building. In conclusion, the overall scum screening and bagging system was designed and is performing as a self-contained system with no odors and minimal human exposure.

REFERENCE


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