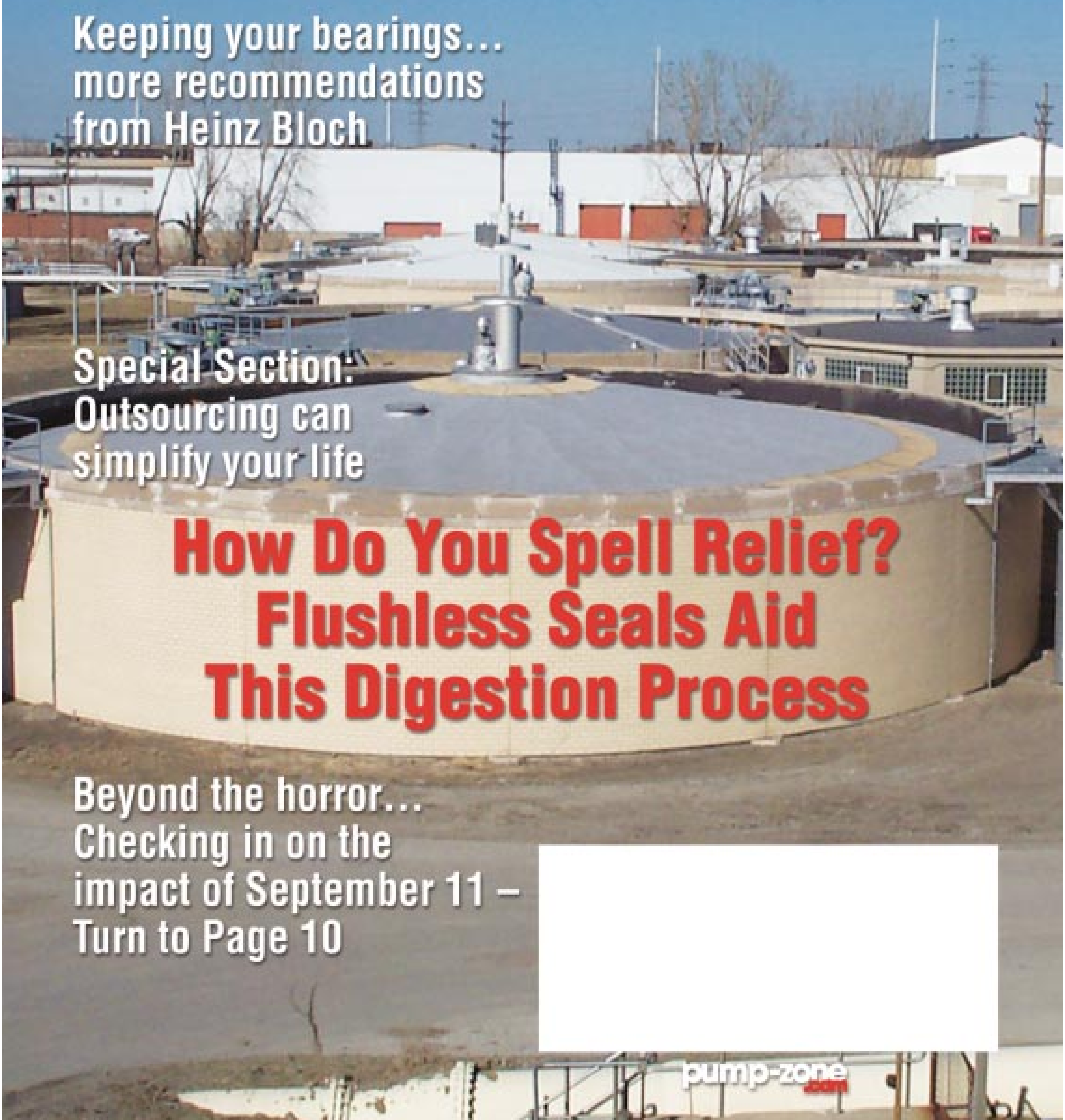
A Randall Publication

PUMPS & SYSTEMS
ROTATING EQUIPMENT

The Magazine for Pump Users Worldwide

October 2001



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How Do You Spell Relief? Flushless Seals Aid This Digestion Process

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Sealed with A Kiss – Improved Biosolids Reduction with Flushless Sealing Technologies

Dilution was NOT the solution.

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The Hammond Sanitary District (HSD) operates a 48 million-gallon per day (mgd) wastewater treatment plant in Hammond, Indiana. Annually, approximately 40,000 wet tons of waste solids are thickened prior to anaerobic digestion, with subsequent dewatering and land application. In an effort to reduce operating costs, HSD initiated a comprehensive capital improvement program, specifically targeted on the anaerobic-digestion process.

Frequently, the key to successful large-scale projects lies in attention to small details. As part of the program to optimize digester loading, process pumps were upgraded to include flushless mechanical seals. This installation of flushless slurry seals on the digester-process pumps was an important part of the optimization project.

The installation of these seals, along with automated pumping, increased gas compressor efficiency and better dewatering techniques saves HSD $200,000 annually.

The Process

Anaerobic digestion of organics has long been a chosen process for treatment of wastewater solids, and is the only unit operation available to wastewater treatment operators that generates actual income for the plant. Anaerobic microorganisms destroy mass, and produce methane gas as a byproduct during the digestion process. Mass destruction reduces solids disposal costs, and methane gas (650 Btu/ft^3) can be utilized in lieu of utility gas.

For proper operation, this time-tested technology requires constant temperatures, steady-state feed rates of a consistent food supply (for the anaerobes), sufficient mixing and time to react. To maintain healthy microorganisms, reactor temperatures must be maintained between 95 and 100 degrees Fahrenheit (°F). HSD drives this process control point to 100°F, opting to maximize kinetic activity.

Influent sludge is fed to the digesters through shell-and-tube heat exchangers (total sludge heating capacity = 3.3 Mbtu/hr). The 160°F hot water used in the heat exchangers is provided by two 6.1 Mbtu/hr boilers, each fired by digester-produced methane gas. Pumps re-circulate the digester contents continuously through the heat exchanger, at 300 gallons per minute (gpm). Centrifugal pumps with a recessed-impeller design, common to many wastewater plants, provide the re-circulation, and are powered by 20-hp motors.

Early in 1998, automated digester-feeding and transferring equipment was installed and made operational. At the heart of this system is a steady, slow (about 100 gpm), controlled feed, automatically distributed among six primary digesters on a rotating schedule, along with control of temperature variations to no more than 1°F. With steady feeding and constant temperatures, and with pumps in place to provide mixing, HSD examined the final component needed for good digestion – detention time.

The pumps were originally supplied with standard packing glands, mechanical packing, and lantern rings for fluid sealing. At some point previous to this

Photo 1. Condition-monitoring peripherals, installed subsequent to the optimization

optimization effort, the packing had been replaced with mechanical seals using flush water. These seals required little or no attention, and eliminated many secondary failures resulting from neglected packed systems (such as sleeve or shaft damage). However, close review of water flowrates to the seals was somewhat surprising. A total of about 20 gpm was being added to the digesters.

This dilution effect may initially appear negligible, but actually reduced average digester-detention times by about 9% (enough to cut a 20-day detention-time schedule to 18.2 days). Reduced digester detention times are evidenced by a decrease in volatile-solids reduction (VSR). This dilution did not render the process ineffective, but did represent an inefficiency that increased downstream unit costs as the sludge was processed in subsequent operations. Sludge with high volatiles does not dewater well, requires more polymer, and yields a wetter cake. More water in the cake increases transportation costs as the biosolids are transported to land application or landfill sites. With this in mind, HSD decided to look at replacing the old-style flush seals with newer technology.

The Application

Hammond Sanitary decided to install flushless mechanical seals on the re-circulation pumps, eliminating the flush water entirely. The seal selected incorporated design features targeted at the two biggest problems associated with slurry seals, heat and equipment motion. External finger springs keep seal faces closed through axial motion (+/- 0.25 inch), and keep friction to a minimum. A patented self-centering lock ring secures the seal to the shaft, assuring that seal faces are aligned square. This is critical to proper operation, as the seal faces are flat to within 3 microns from the factory. The fact that the seal manufacturer had provided years of quality field service, and engineering support at the plant, working hard to keep their mechanical seals up and running, affected the seal selection.

Although the pumps had originally been designed for packing, the only modification needed to adapt to the seal was machining the stuffing box "square to the shaft" for proper seating of the seal gland gasket. The material chosen for both the stationary and rotary seal faces was tungsten carbide. The first set of seals was installed, with the turnaround time averaging about 8 hours. Figure 1 shows a cut-away of the seal design chosen.

The Problem

With the flushless seals in place, water dilution of the digester feed product was

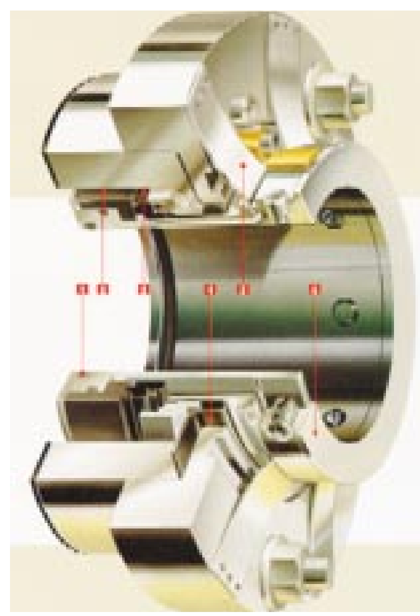

Figure 1. Flushless slurry seal cut-away, 1- O-ring, 2- open gland chamber, 3-seal face, 4-diaphragm, 5- springs, 6- lock ring (156 Heavy Duty Slurry Seal, source: A.W. Chesterton Company, Stoneham, MA)

eliminated, and the test began. Problems started occurring shortly after installation. Sludge was leaking out of the seals, profusely at times. The leaks were intermittent, sometimes stopping as fast as they started, other times persisting for many hours. HSD immediately piped a flush-water line to the stuffing box, allowing cleaning of the seal internals and the stuffing-box cavity. This proved to be temporarily effective in stopping the leaks, but there was no time-pattern to the seal failure. Sometimes, days would pass with no problems. Other times, it was necessary to provide the external flush several times a day.

The seal manufacturer's field technicians and application engineers came to the plant, reviewed the application, and started working on a solution with HSD personnel. Root-cause failure analysis identified the problem source. A pressure gauge and a valve were installed, using the tapped flush-line hole on the stuffing box. A large rush of air was released each time the valve was opened, clearly indicating an air-locked, or "fluidless" condition at the seal faces. The pressure gauge showed little or no pressure in the stuffing box. With no fluid to help carry away the heat generated at the seal faces, temperatures quickly climbed to excessive levels. When the seal ran long in this condition, the tungsten carbide faces "heat checked" and eventually cracked. The impeller pump-out vane geometry was drawing process fluid away from the stuffing box, which was practical for the original packed-pump design but not good for the slurry-seal application.

The Solution

With the root cause determined and engineered solutions being reviewed, the pumps were still operating, but causing fits. HSD decided to slow the speed of the pumps down in an effort to reduce friction, thereby lowering the temperature and reducing the hydraulic effect of the impeller on the stuffing box. Flow rates were reduced to 250 gpm, down from 300 gpm but still more than adequate. At the new pump flow of 250 gpm, the digester contents still would be turned over every 2.5 days, which was acceptable in light of the benefits of keeping the seals in service with no solids dilution from seal water.

The manufacturer offered a solution consisting of two key elements. The first change was in the material for the seal faces. Tungsten carbide is the hardest non-brittle face material available, but has a high coefficient of friction (0.16). "Duplex Carbide," a proprietary face material offered by the seal vendor, has excellent hardness characteristics and a coefficient of friction one-quarter that of tungsten carbide (0.04). The material change would reduce seal operating temperatures, but process fluid still had to be present in order to carry away the heat generated at the seal faces.

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Element two of the solution was to get the process fluid into the seal cavity, and to get the air out. A unique throat bushing was installed to gain the desired effect. The bushing is designed with spiraled grooves that create circulation into and out of the seal cavity. This is a forced exchange, and expels not only trapped air, but also particulates that are suspended in the fluid.

This combination of system design changes proved quite effective. The reduced pump speed, Duplex Carbide stationary seal face, and the spiraled throat bushing, all seem like small changes by themselves. However, when combined, they made the difference between a non-functioning system and an optimized one.

Operators only flush the seals once per shift as part of their daily rounds. More importantly, feed sludge is no longer being diluted, taking up valuable digester space, and reducing detention times.

In the end, the application of the slurry seal was more complicated than originally anticipated, but the fix emphasized the importance of selecting a manufacturer that will support its product after the sale.

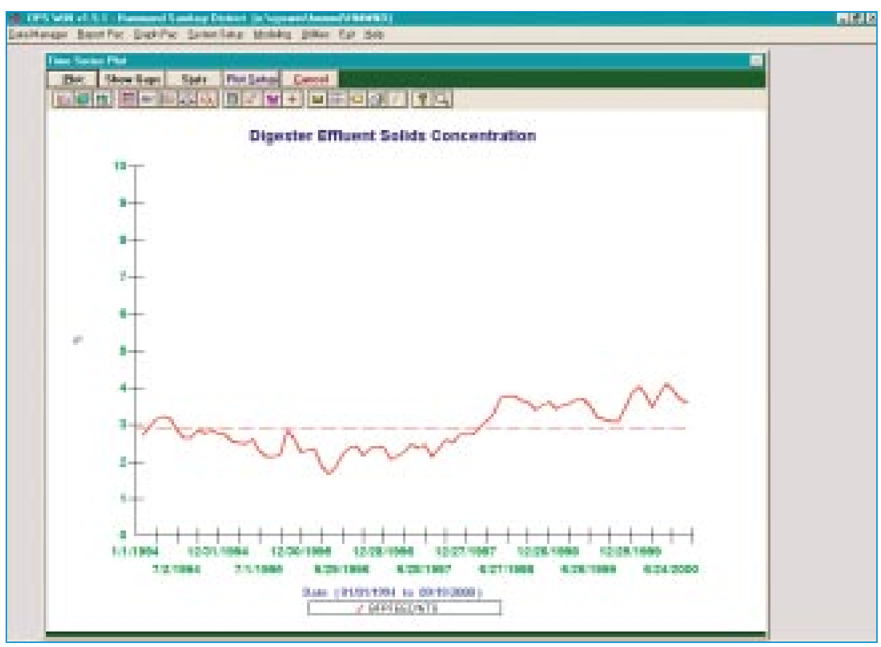

Figure 2. Increased solids concentration.

Costs and Savings

The cost of the slurry seal, complete with the spiraled throat bushing, Duplex Carbide stationary face, and stuffing box machining, was $3,700 (for a shaft size of 2 inches). Material-to-labor ratio for the installation of 6 seals was 1.9, putting the installed unit cost at about $5,700. A total project cost to refit all the pumps associated with the digesters was $37,200.

This installation was a component of the larger digester-efficiency project, and not all the subsequent cost savings are directly attributable only to the mechanical seal. However, an increase in solids concentration is *entirely* due to the reduction in flush-water dilution. Figure 2 shows the digester effluent solids concentration over a 6-year time period. Note the increase at the start of 1998, when the project was initiated, with completion early that same year.

HSD uses belt filter presses to dewater sludge prior to land application, and realizes savings of $50,000 per year in disposal costs for each 1% solids increase. Payback period, based only on the 1% solids increase obtained, was less than 9 months. Bear in mind that there is a multiplying effect as the sludge is processed further downstream. Savings not easily linked to the seal project, yet directly influenced by it, include increased volatiles destruction and increased gas production. Figure 3 shows the volatile-solids destruction over a 4 year time period, and clearly shows better digester performance, as volatile solids reduction (VSR) now consistently exceeds 60%.

It's payback time.

Based only on volume reduction,

$$\frac{\text{Investment}}{\text{Return}} = \frac{\text{Installation}}{\text{Savings}} = \frac{\$37{,}200}{\$50{,}000/\text{yr}} = .744 \text{ yr}$$

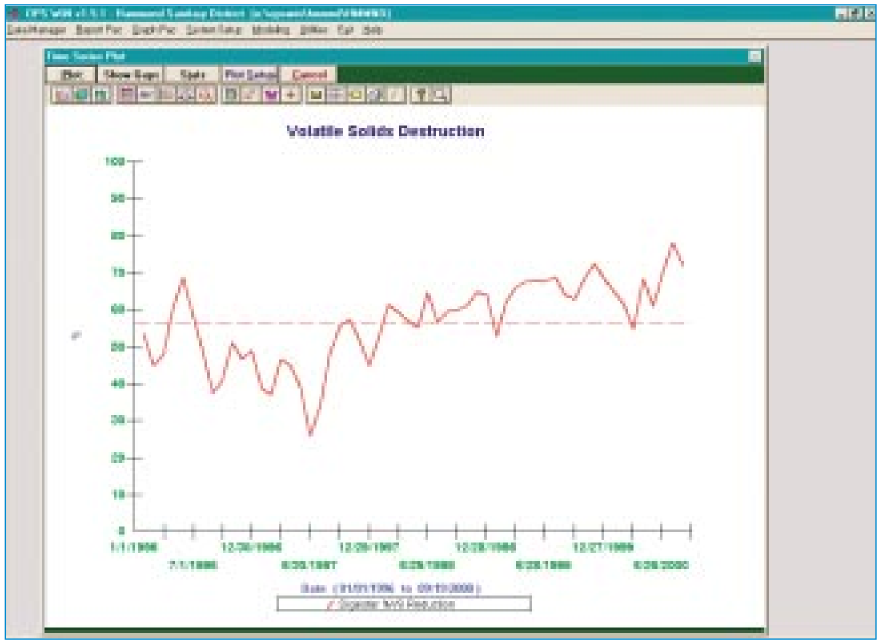

Figure 3. Increased volatile-solids destruction.

Conclusion

The intent of this project was to go the extra step, and turn digester operations into a highly efficient process. The step from good to excellent is often the hardest, as the details can easily be written off as insignificant. Installation of the flushless slurry seals has proven effective, and saves money. Persistent effort from all parties involved has proven well worth the tribulation. ■

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Acknowledgement

The authors acknowledge and appreciate the diligent assistance of Todd Kramer, Senior Specialist for the A.W. Chesterton Company, in the seal application and resolution presented here.

(Editor's Note: This article is adapted from "Improved Biosolids Reduction with *Flushless Sealing Technologies –"Sealed with a Kiss*," by Richard Sutton, P.E., and Michael T. Unger, PhD., and published here with permission of the authors. Readers interested in the seal configuration presented here are directed to William "Doc" Burke, of A.W. Chesterton Company, whose assistance in the development of this article is acknowledged and appreciated.