By Esther Mendez & Elena Bailey

Digestion dilemma

Two wastewater treatment plants (WWTPs) cut costs and meet effluent limits using prethickened aerobic digestion with membrane thickener

In 2005, Enviroquip, a division of Eimco Water Technologies (EWT), began operating two historic membrane bioreactor (MBR) plants—the Dundee WWTP in Dundee, Mich., and the McFarland Creek WWTP in Bainbridge Township, Ohio. These two WWTPs were existing conventional plants. Both needed to expand in order to meet future flows and demands due to overall growth and development in their respective areas.

In 2003, the village of Dundee began upgrading its plant. The decision to expand was made based on the modifications enforced by the Michigan Department of Environmental Quality (MDEQ), which mandated lower plant discharge limits due to water in the receiving stream not meeting federal quality standards. The McFarland Creek WWTP also had to expand its existing plant capacity by 50% due to continued regional growth. Both of the facilities' engineering firms reviewed available technologies to determine the most suitable equipment for the expansion projects and concluded that MBR technology was the best option.

The technology proposed for both plants was an MBR system for the biological process and the PAD-K system (prethickened aerobic digestion with membrane thickener) for the sludge treatment process. The PAD-K system provides integrated operation of a Kubota flat-plate membrane thickener and two or more aerobic digesters. By operating these units as a combined system, improved treatment is achieved.

McFarland WWTP's goals were to retrofit existing digesters and reduce sludge disposal cost by a minimum of 20%. For the village of Dundee, the main goal was to reduce sludge production by 30% and increase sludge storage capacity from 120 to 180 days. The upgrade from sequencing batch reactors (SBRs) to MBRs in combination with the PAD-K process was targeted to meet stricter effluent limits and handle a higher solids load without additional storage tanks.

Dundee's upgrade

The plant was upgraded from a rated capacity of 0.75 million gal per day (mgd)—the actual flow in the year 2003—to a full built out capacity of 2 mgd average daily flow and 4 mgd peak daily flow. In 2006, the actual flow into the MBR was an average of 1.5 mgd. The new MBR facility utilizes most of the existing tankage. The former SBR basins were used as the biological basins for the new system, and new MBR basins were constructed adjacent to the existing tanks.

The MBR facility uses a three-stage process: an anoxic zone for denitrification, a pre-air zone for nitrification and an MBR zone for additional nitrification and complete filtration. The existing aerobic digestion system was also upgraded by adding a membrane thickening basin (MBT) to the two existing aerobic digesters to form the new PAD-K system. Each aerobic digester forms a recycle loop with the MBT at a steady state.

The MBT operates in loop with a digester anywhere from eight to 24 hours per day, depending on the wasting rate from the MBR. During that time, the digester in loop continuously thickens while undergoing both nitrification and denitrification. Nitrification/denitrification is controlled using an oxidation reduction potential system. Blowers are on during nitrification and off during denitrification.

While the first digester is in loop with the MBT, the second is in isolation to provide additional volatile solids reduction and pathogen reduction to meet the requirements of Class B sludge. For Class B criteria, the actual volatile solid requirement is 38% and a standard oxygen uptake rate at 68°F (20°C) of less

FIGURE 1: Dundee, MI - PAD-K Membrane Thickener/Digestion Process Layout

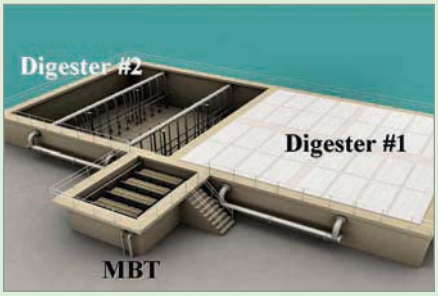

FIGURE 2: Dundee, MI - Typical PAD-K MBR Thickener/Digestion Process Layout

than 1.5 mg oxygen/hr/g total solids. Class B criteria also has pathogen reduction requirements, including fecal coliform density of less than 2,000,000 MPN/g total dry solids.

As a result, high quality permeate from the MBT attains concentrations of biochemical oxygen demand (BOD) and total nitrogen (NH_3-N and NO_3-N) within the National Pollutant Elimination System permit and can be combined with MBR effluent. The second objective for the plant was to reduce the hauling to two times per year, as the system lacked sufficient storage volume to retain digested sludge throughout the winter.

The PAD-K process expanded the sludge holding capabilities of the existing digester basins significantly, and the MBT integrated into the digestion process continuously reduced the sludge stored in the digester basins. This reduction in sludge volume is beneficial to plant operations because it allows the sludge to be dewatered in less time, saving on sludge handling costs and operation of dewatering equipment. The PAD-K process was designed at 4.5°C and is capable of concentrating the waste sludge from a range of 3 to 5% solids, significantly expanding the solids retention capabilities of the digesters to 180 days.

A summary of yearly savings is presented in the sludge handling cost summary table (Figure 4). For 2003 and 2004, as well as the first part of 2005, the usage of a belt press was implemented due to the lack of storage space. Since the lateral part of 2005 (upon completion of the PAD-K system and operating for all 12 months in 2006), results clearly show a reduction of annual cost from previous years. For example, based on the sludge handling cost shown in Figure 4, when the flow to the plant was 0.75 mgd, the yearly cost was $56,880; in 2006, when the flow to the plant was 1.5 mgd, the sludge handling cost was significantly less—$32,739.

McFarland Creek's upgrade

McFarland Creek WWTP was upgraded from 1.2 to 1.8 mgd using the existing tankage and footprint from the conventional facility, thus reducing construction costs and time. The McFarland Creek WWTP MBR system consists of a two-stage process: an anoxic zone and an MBR zone where two of the existing aeration basins were converted to two anoxic zones and four membrane basins.

The PAD-K system was incorporated in this plant by installing new membrane thickener systems in two existing digesters. Thickening, digestion and nitrification/denitrification occur in each digester. The system was designed to operate at 10 to 12°C, with a design solid concentration of 2.5 to 3% in Digester No. 1 and 3.5 to 4% in Digester No. 2, meeting the objective of Class B and reducing the sludge disposal cost by more than 20%.

Digesters in this facility are able to operate both in series and in parallel based on the loading rates to the plant and dewatering cycle. The plant gained exceptional solids processing savings of 41% reduction in cubic yards produced, 41% cost savings in polymer by using the MBT system and 41% savings in sludge disposal by using the PAD-K system.

Savings and control

EWT has 40 membrane thickener applications worldwide, with more than 25 PAD-K process-incorporated facilities in the U.S. and the remaining in the U.K. The PAD-K process is ideal for MBR applications or conventional processes, such as oxidation ditches and SBR processes designed to meet strict effluent nutrient limits of total nitrogen and phosphorus.

The flat-plate technology is being used as a simple and reliable way to thicken sludge and post-thicken digested product without the use of polymer addition. Cleaning frequency of membranes is limited to twice a year in-place without the need to drain the membrane-thickening basin. EWT has combined the PAD-K systems with the MBR permeate as a standard design in all recent installations.

Overall, by providing the option of a PAD-K process to the McFarland and Dundee WWTPs, the company provided the benefits of improved footprint, significant energy savings, sludge handling savings and ultimate nutrient control, providing the opportunity for blending with the MBR effluent. MT

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FIGURE 3: Permeate Quality Chart

Dundee WWTP, Michigan

Permeate Quality
before it's blended with MBR effluent

BOD:	<1.0	mg/l
TSS:	<2.0	mg/l
NH_3-N:	<0.12	mg/l
NO_3-N:	<3.0	mg/l
TP:	<7.0	mg/l

Note: Combined effluent is not disinfected prior to discharge

* Highest solids concentration achieved in MBT to date 5.75%.

FIGURE 4: Dundee, MI - Sludge Handling Cost Summary

Years	Gallons Hauled	Dry Tons	Yearly Cost
2001	1,483,200	125.53	$35,258 – No MBT
2002	1,425,600	114.55	$43,196 – No MBT
2003 Q_{Actual} = 0.75 MGD	313,000 – Belt 1,102,600 – Truck 1,415,600 - Total	24.80 – Belt 80.05 – Truck 104.85 - Total	$21,290 – Belt $35,590 – Truck $56,880 - Total
2004	248,885 – Belt 943,200 – Truck 1,192,100 - Total	22.67 – Belt 99.39 – Truck 122.06 - Total	$16,850 – Belt $30,088 – Truck $46,938 - Total
2005 MBT operational for 2nd half of year only	572,400 – Belt 432,000 – MBT 1,004,400 - Total	55.62 – Belt 47.55 – MBT 103.17 - Total	$39,135 – Belt $14,623 – MBT $53,758 – Total
2006 Q_{Actual} = 1.5 MGD	887,400 - MBT	130.48 - MBT	$32,739 - MBT

Belt press was needed for years 2003 -05 due to lack of storage space

Sludge hauling costs for first full year of operation of MBT in 2006 was $32,739, which is cheaper than the last five years.

FIGURE 5: McFarland, OH - Solids Production and Volume 2004 vs 2006