A TYPICAL AERATION UPGRADE – CONSIDERATIONS AND OUTCOMES

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ABSTRACT

Most modern sewage treatment involves aeration in an activated sludge process. A typical activated sludge process plant may consume between 50 and 60% of the total power consumed by the complete treatment process.[1] This paper reviews steps taken, in a typical upgrade of a medium sized plant, to replace diffusers, optimize the aeration controls and to minimise power consumption.

1.0 INTRODUCTION

The plant considered in this investigation is Hunter Water Corporation’s Edgeworth WWTW at Edgeworth near Newcastle .

This plant is a Modified Ludzack- Ettinger (MLE) design of continuous activated sludge process and was designed for an EP of 70,000. It currently treats approximately 14 ML per day[2]. In 1996 the plant was fitted with fine bubble porous diffusers fixed to the floor on a grid of uPVC pipework, the diffusers were renewed in 2005. An aeration upgrade was carried out in 2009/10 on which the author has based this paper.

2.0 DISCUSSION

2.1 Aeration Review

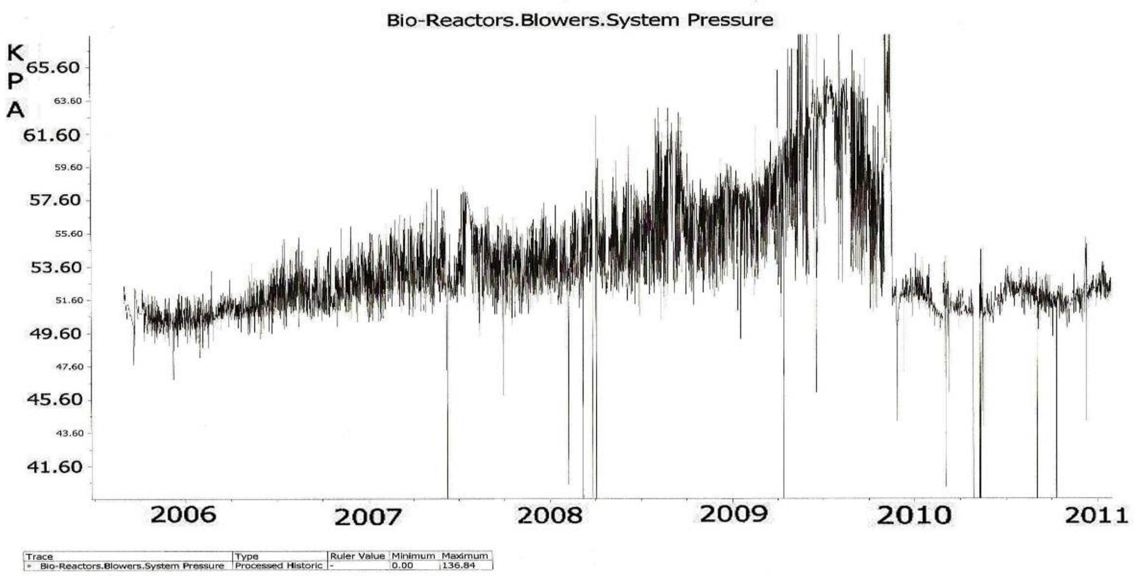
The 2009 upgrade of the Edgeworth WWTW involved a complete review of the aeration process and included:

- Replacing the porous diffusers with larger membrane diffusers better able to withstand interruptions to the air supply.
- Providing additional aeration capacity for future load increases.
- Providing greater tapered aeration to optimise the anoxic zone effectiveness
- Upgrading the existing blower system.
- Providing motorised control valves on the air supply pipework to the tanks.
- Providing new instrumentation for greater and more reliable control.
- Modifying the control system to allow multiple modes of aeration control in the event of failures.
- Providing facilities to monitor and maintain the diffusers.

2.2 Upgrade Requirements

At Edgeworth WWTW there are 2 aeration tanks, each of which is 45.1m long by 24.0m wide with a maximum liquid depth of 5.0m. Within the tanks there is an anoxic zone which is separated from the aeration zone by a fully submerged stub wall 2m high with a 4 m wide gap on the side opposite the MLR pipework. The MLR flows from the outlet end to penetrate the stub wall at the anoxic zone and is formed from 1.5m wide upturned culvert sections being laid on the tank floor adjacent to the tank wall after the tank had been constructed.

In the years prior to the latest upgrade the existing aeration diffusers had gradually become fouled due to periodic blower outages and inability to carry out "on- line" periodic maintenance. The classic increase in backpressure shows on the following trend chart. Refer figure 1



<u>Figure 1:</u> ***Increase in system backpressure***

Process requirements were considered and the parameters for the upgrade were determined as shown in Table 1 below.

<u>Table 1:</u> ***Plant design requirements***

PEAK SOTR	Present 750 kgO_2/hr	2030 Future 1,040 kgO_2/hr
PEAK AIRFLOW	Present 11,000 m^3/hr	2030 Future 12,690 m^3/hr

In order to make the de-nitrification more efficient the existing graded aeration was to be changed as shown below in Table 2.

<u>Table 2:</u> ***Grading of oxygen in the tanks***

% OF TOTAL OXYGEN / TANK DELIVERED TO EACH ZONE		
	Existing	***Proposed***
ZONE 1	40%	50%
ZONE 2	32%	33%
ZONE 3	28%	17%

2.3 Other issues to be considered

The existing blowers were not only aging but of differing types which, when operating together, made controls a problem.

Due to the need to replace the fouled and aged diffusers, and in recognition of the power outages encountered at the plant it was decided to change the diffusers from porous discs to membranes with greater surface area, and capable of fitting on to the existing bodies and pipework.

This presented a challenge, as the greater kgO2/hr could be achieved by replacing the existing 210mm diffusers with 300mm diffusers but this would generate too great an oxygen transfer with too little taper. Diffusers were required to be blanked off in zones 2 and 3.

The DO levels in each of the tanks varied considerably, in some cases by more than 30%. This was a critical issue as the plant is required to operate at an unusually low level of DO of 0.5mg/ L. Over the past the operators have changed the air flows to each tank by adjusting a manual butterfly valve in the header, effectively using an isolation valve as a flow control valve.

2.4 Solutions Adopted

The blowers chosen were the latest generation of centrifugal high speed turbines driven through VF drives at very high motor speeds, and the benefits of small footprint, low noise level and air bearings resulted in high efficiency and low maintenance.

Main digital operating functions, such as Ready, Run, Alarm, Fault, and Power were hardwired to the PLC. The analogue set value (current in this case) was also hard wired. The blower local PLC was connected via optic fibre to the main PLC, thus giving total visibility to the plant of all the conditions within the blower.

The DO probes chosen were the latest galvanic type oxygen cells with the oxygen analyzer designed for continuous monitoring. The probes were automatically cleaned every 24 hours by water jet. Each tank now has 4 DO probes, one in the anoxic zone and 3 in the aerobic zone, 1 in each of the aerated zones.

Flow meters, to check the air flow to each of the tanks, were chosen as thermal mass flow meters.

Pressure and temperature measurement are built in to each of the blowers

The existing manually actuated full bore isolating valves were maintained and actuators were added. Although being full bore and not ideal for modulating flow control, it was determined that these valves would be suitable for trimming control. Power would be saved by not changing to smaller bore valves with better control characteristics, as this would have involved a greater system back pressure. The actuators were set to trim to an algorithm every 10 minutes with a maximum of 2% change each movement.

As tank 2 showed greater DO, tank 1 valve was maintained at 100%. Tank 2 valve modulated in accordance with figure 2 shown below.

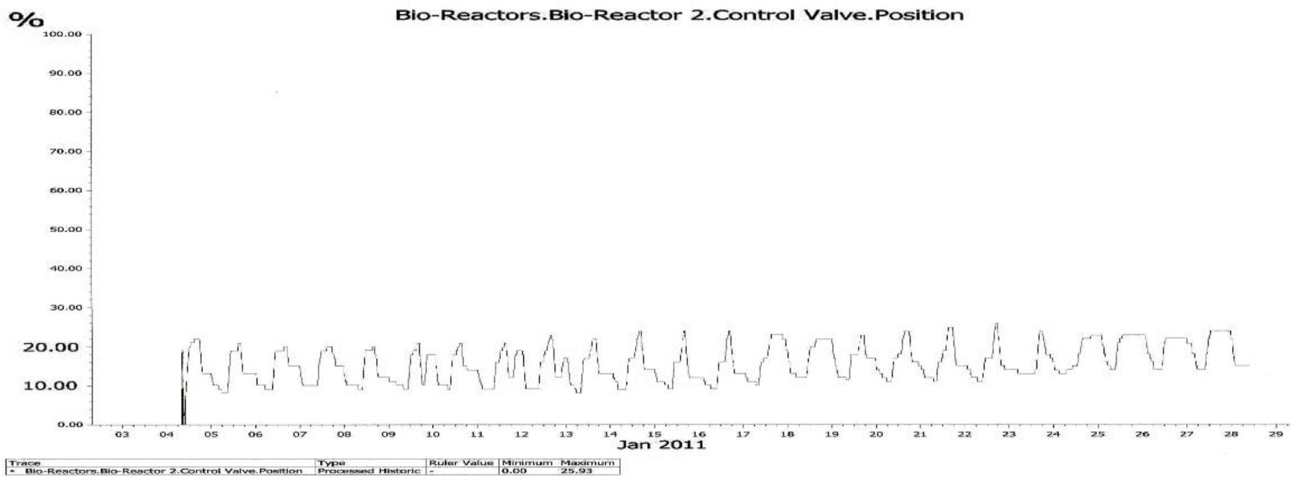


Figure 2: ***Tank 2 control valve position*.**

The diffusers were changed from 215 dia sintered polyethylene porous diffusers to 300 dia EPDM rubber membrane diffusers, from the Nopon range of products.

Downtime in the tanks was restricted to 1 week for draining, cleaning, and replacing the diffusers, with work not to be carried out in the peak summer months.

Three different control modes were finally adopted for the control of the aeration system.

- **Mode 1.** The 6 DO meters from the aerobic zones of the tanks are averaged and the resulting value is used to increase or decrease the blower output accordingly. The average of the 3 DO meters in each tank is also used to adjust the flow and therefore the DO between the 2 tanks by trimming the main header isolating valve. The DO readings are taken every 10 minutes and the valve position changes, operate in 2% increments.

- **Mode 2** This mode is adopted if none of the DO meters are operating or are unavailable. The plant influent data is used to compute the required total airflow required. An algorithm sets the blowers to provide the required airflow.

- **Mode 3.** This mode is adopted if none of the DO meters are operating and if one or more of the flow meters is not operating or available. The PLC will review the histogram of tabulated output settings from the previous 24hrs of operation, and set the blowers accordingly.

Blowers change over after 7 days. Where one blower operates at 95% then the second blower comes on to assist, they then both ramp up from a 45% speed.
Resultant average DO in each tank is shown in figure 3 below.

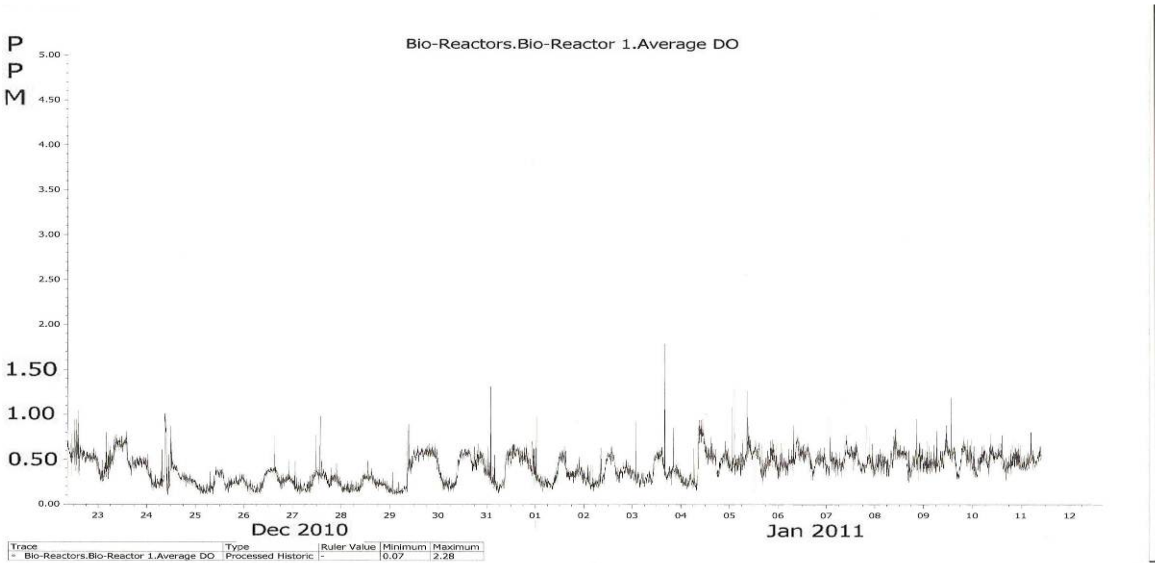


Figure 3: *Average DO in tank 1*

Diffusers, being EPDM membrane type, have had their droppers modified to include for in-line monitoring. The sockets added allow for pressure and flow monitoring as well as a dosing point for formic acid. See figure 4 below.

Figure 4: *Diffuser maintenance fittings*

The air pipe offtakes shown are the anubar flow meter offtake before the valve, followed by the offtake with valve and plastic tubing for line pressure. This plastic tubing terminates in the gang plate, as shown, where direct dP measurements can be taken for pressure drop across the diffusers. The nozzle furthest out near the dropper bend into the tank is the injection point for formic acid.

3.0 CONCLUSIONS

- Aeration capacity has been increased by 38%.
- The aeration control system is more flexible, reliable and has been simplified.
- The air distribution between the two tanks is now automatically controlled.
- The diffusers are now more able to withstand air outages without adverse consequences.
- The diffusers are able to be regularly monitored and maintained without taking offline, thus prolonging their effective service life.
- The latest generation of blowers are effectively maintenance free.
- NH3 and BOD7 levels have continued to meet plant requirements.
- Aeration efficiency has increased by approximately 45%. Before the upgrade peak load involved 2 x 90 kW blowers operating at 90%. After the upgrade one blower is almost coping with 90kW.

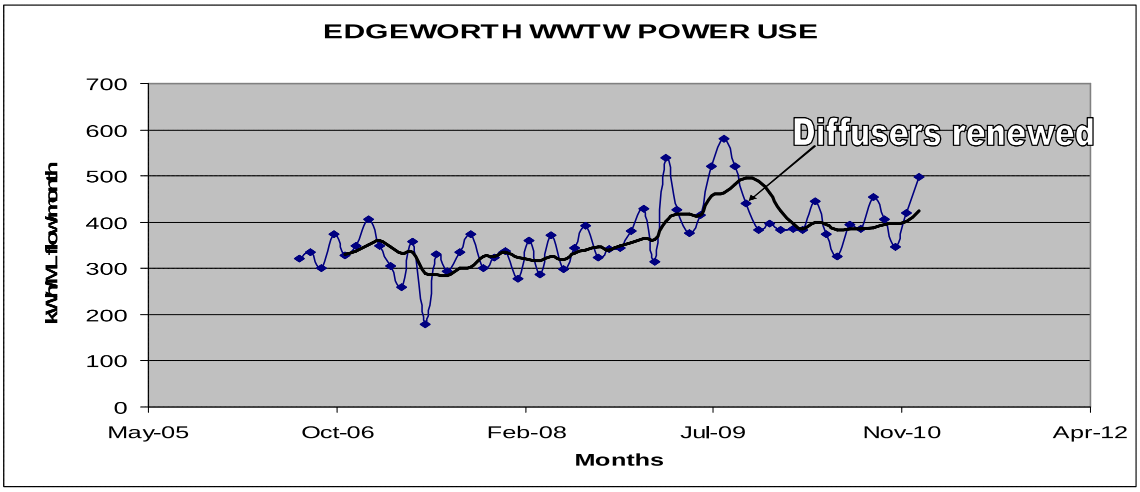


Figure 5: *Plant power consumption*

4.0 ACKNOWLEDGEM ENTS

Abergeldie Young Process Engineering Pty. Ltd., Aeration Upgrade Contractor
Dao Norath, Tom Cordingly – Hunter Water Corporation.
John Stevens – Hunter Water Australia,
Tom Lawson – Aer-Force diffuser replacement maintenance and supply.

5.0 REFERENCES

1. Wastewater Engineering by Metcalf and Eddy 2003 edition chapter 15 p 1704.

2. Hunter Water Website and existing plant SCADA data.