The Iron Bridge Bardenpho System… A Great Process Made Better!

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The Bardenpho process modification project has allowed the decommissioning the failing rotating biological contactor (RBC) process at Orlando's Iron Bridge Regional Water Reclamation Facility without a reduction in the facility's permitted treatment capacity. The project goal was to identify and obtain the maximum treatment capacity for the existing Bardenpho process to treat flows significantly above the original design value. The city's anticipated savings in averted capital for new process tankage to replace the lost RBC permitted capacity of 16 million gallons per day (mgd) exceeds $40 million dollars.

Currently the Iron Bridge facility is permitted for a total treatment capacity of 40 mgd. As a result of process modifications, each of the four Bardenpho process trains, initially designed to treat 6 mgd, has been rerated through the Florida Department of Environmental Protection to treat 10 mgd. Each Bardenpho train has been modified to include two 150-horsepower (hp) mechanical aerators with variable frequency drive (VFD) units for speed control, and coarse-bubble diffusers supplied by 200-hp blowers to provide supplemental aeration within the Carrousel aerobic zones.

Fermentation Zone Baffle Walls

The city and consultants are currently designing various modifications to the existing Bardenpho trains to enhance performance in fermentation, first anoxic and second anoxic zones. Baffle walls will be installed in the beginning of the fermentation zone to promote quicker reaction of the fermentation process by enhancing "plug flow," resulting in an increased food-to-microorganisms (F/M) ratio in the first portion of the fermentation zone.

Step-Feed of Internal Recycle Flow

Denitrification efficiency in the first anoxic zone will be enhanced by step-feeding internal recycle (IR). Modifications will be made to allow portions of the IR flow to be fed to the second half of the fermentation zone, provided the required reactions can be accomplished within the first half of the fermentation zone. A portion of the IR flow can also be applied to the beginning of the original first anoxic zone.

First Anoxic Zone - Extended Aerobic Time

Another baffle wall will be installed to equally divide the first anoxic tank. The first half of this tank will remain as traditional anoxic; however, the second half of the tank will be equipped with a fine-bubble diffused aeration system. Based on the degree of denitrification, as measured by the nitrate concentration entering the second half of the first anoxic zone, the aeration control system will select operation of the second half of the first anoxic zone in a traditional mixed anoxic environment, or in an aerobic environment extending the overall nitrification zone.

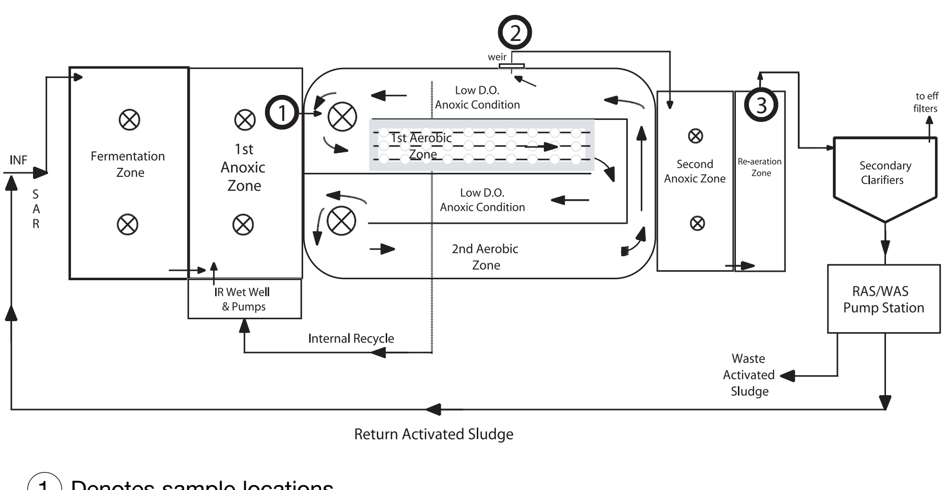

Figure 1: Bardenpho Train Flow Pattern and Sample Locations

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Carrousel Supplemental Aeration

Each Bardenpho train has been equipped with a coarse-bubble diffused aeration grid installed by city crews in the first aerobic zone of the Carrousel aeration tank. The additional aeration has allowed the total treatment capacity of the Bardenpho process to be expanded from 24 mgd to 40 mgd. Future modifications are being designed to include installation of fine-bubble diffused aeration to improve oxygen transfer efficiency.

Lower Mixing Impellers

Each mechanical aerator has been modified with lower mixing impellers to improve efficiency in the Carrousel channels and to maximize distribution of the applied oxygen. Based on visual observations, it appears that the lower mixing impeller has improved the velocity profile through the aerobic zones of the Carrousel tank.

Increasing Zone Operating Levels

The original design of each train provided a free-fall over the Carrousel outlet weir fluctuating between two to three feet (depending on the position of the adjustable weir) as the mixed liquor discharged to the second anoxic tank. Air entrainment into the mixed liquor, just before entering the second anoxic zone, slowed the reaction of denitrification within the initial zone of the second anoxic basin.

The goal was to decrease the existing free-fall over the Carrousel weir. Slightly closing the outlet under-flow sluice gate of the re-aeration basin increased the operating levels in the second anoxic and re-aera-

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Process Area	Equipment/ Component	#	Design Criteria	Rerate Criteria
Bardenpho	Bardenpho Trains	4	6 mgd Avg Capacity Each	10 mgd Avg Capacity Each
	Fermentation Tanks	4	606,000 Gallons per Tank 2,424,000 Total Gallons for All Fermentation Tanks	606,000 Gallons per Tank 2,424,000 Total Gallons for All Fermentation Tanks
	Fermentation Mixers	8	Two Mixers per Tank Low Speed Turbine Mixers	Two Mixers per Tank Low Speed Turbine Mixers
	First Anoxic Tanks	4	606,000 Gallons per Tank 2,424,000 Total Gallons for All First Anoxic Tanks	606,000 Gallons per Tank 2,424,000 Total Gallons for All First Anoxic Tanks
	First Anoxic Mixers	8	Two Mixers per Tank Low Speed Turbine Mixers	Two Mixers per Tank Low Speed Turbine Mixers
	Carrousel Aeration Tanks	4	2,630,000 Gallons per Tank 10,520,000 Total Gallons for All Aeration Tanks	2,630,000 Gallons per Tank 10,520,000 Total Gallons for All Aeration Tanks One 200 hp Blower per Tank for Supplemental Diffused Aeration
	Surface Mechanical Aerators	8	Two Aerators per Tank with Two-Speed Motors, 150 HP Motor	Two Aerators per Tank with VFD Drives 150 HP Motor
	Second Anoxic Tanks	4	890,000 Gallons per Tank 3,560,000 Total Gallons for All Second Anoxic Tanks	1,035,636 Gallons per Tank 4,142,544 Total Gallons for All Second Anoxic Tanks
	Second Anoxic Mixers	8	Two Mixers per Tank Low Speed Turbine Mixers	Two Mixers per Tank Low Speed Turbine Mixers
	Reaeration Tanks	4	Coarse Bubble Diffused Aeration 150,000 Gallons per Tank 600,000 Total Gallons for All Reaeration Tanks	Coarse Bubble Diffused Aeration 174,545 Gallons per Tank 698,180 Total Gallons for All Reaeration Tanks
	IR Pump Stations	4	36 mgd Max per Train	36 mgd Max per Train
	Total IR Pumps	12	Propeller Pumps Float Controlled 6 mgd Capacity Each Pump	Propeller Pumps Float Controlled 6 mgd Capacity Each Pump
Secondary Clarifiers	Secondary Clarifiers	8	100 Foot Diameter Tanks 3 mgd Avg Capacity Each Draft Tube RAS Removal	100 Foot Diameter Tanks 5 mgd Avg Capacity Each Draft Tube RAS Removal
RAS/WAS Stations	RAS/WAS Wet Wells	2	Each Station Serves 4 Clarifiers Telescopic Valve for Each Clarifier in the RAS/WAS Wet Well	Each Station Serves 4 Clarifiers Telescopic Valve for Each Clarifier in the RAS/WAS Wet Well
	RAS Pumps per Wet Well	3	Two-Speed Motors About 3,000 gpm Each Discharges to Head of Fermentation Tanks	VFD Drives About 3,000 gpm Each Discharges to Head of Fermentation Tanks
	Total RAS Pumps	6		
	WAS Pumps per Wet Well	2	Submersible Pumps	Submersible Pumps
	Total WAS Pumps	4	Constant Speed About 350 gpm Each	Constant Speed About 350 gpm Each

Table 1: Bardenpho Process Equipment Summary

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tion tanks by about 16 percent. This modification has decreased the free-fall over the Carrousel weir to less than one foot. Besides decreasing the dissolved-oxygen (D.O.) level entering the second anoxic tank, another significant benefit has been realized by the increased capacity and treatment detention time in the second anoxic tank and reaeration tank.

Process Sampling & On-Line ChemScan Analyzer (Nitrogen Profile and Phosphorus)

Each Bardenpho train is sampled using submersible chopper pumps at three locations: 1) outlet of the first anoxic tank, 2) Carrousel outlet, and 3) outlet of the re-aeration tank. **Figure 1** depicts the flow pattern and sample locations, typical of each Bardenpho train.

Based on an automatic sequencer system, each MLSS sample is delivered to the ChemScan system and analyzed for NO_2-N, NO_3-N, NH_3-N, and PO_4-P. The respective MLSS sample is filtered in an ultrafiltration module; then the filtrate is supplied to the ChemScan UV analyzer. The ChemScan system performs a UV spectrum analysis to identify the nutrient profile characteristics in about eight minutes per sample location.

The on-line, real-time data generated by the ChemScan analyzer is electronically tabulated, trended, stored in the field device, and simultaneously transmitted to the facility's SCADA system, where it is used for automated control of the Carrousel mechanical VFD aerators. The SCADA control system allows operator-definable ammonia and nitrate setpoints, when compared to the actual ammonia and nitrate values, to control the speed of the mechanical aerator VFD drives.

Mechanical Aerator VFD Speed Control Automation - Based on Process Performance

The aerators are controlled based upon periodic ChemScan readings in the first anoxic, aeration, and re-aeration basins. The "inside" aerator (first anoxic outlet into the Carrousel aeration tank) of each train has been designated as the ammonia/nitrification aerator, and the "outside" aerator as the NO_x/denitrification aerator.

Based upon a calculated value, each aerator is adjusted when one or more of the readings or setpoints are updated. With a re-rate flow volume per train of 10 mgd, the hydraulic residence time (HRT ... time for one complete turnover) of the first anoxic basin is about 20 minutes, the aeration basin about 80 minutes, the second anoxic basin 90 minutes, and the re-aeration basin about 15 minutes.

To achieve nitrification, the inside aerator's speed is adjusted to maintain a target ammonia setpoint value at the aeration basin's weir, while

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being proactive to the ammonia concentration entering the aeration basin from the first anoxic basin. As the ammonia concentration at the weir, or in the first anoxic outlet, rises above the target setpoint value, the speed of the inside aerator is increased, enhancing the nitrification process. Conversely, as the ammonia concentration at the weir, or in the first anoxic outlet, falls below the target setpoint value, the speed of the inside aerator is decreased, enhancing the denitrification process.

To achieve denitrification, the outside aerator's speed is adjusted to maintain nitrate setpoint values at the aeration basin weir and the outlet of the re-aeration basin. As the nitrate concentration at the weir, or the outlet of the re-aeration basin, rises above the target setpoint value, the speed of the outside aerator is decreased, enhancing the denitrification process. Conversely, as the nitrate concentration at the weir, or in the outlet of the re-aeration basin, falls below the target setpoint value, the speed of the outside aerator is increased, enhancing the nitrification process.

Under the present ChemScan operating scheme, the output speed of each train's mechanical aerators is adjusted about three times per hour ... more frequently than manual adjustments could be made without significantly increasing staffing levels. It is estimated that the operator labor required to make the same degree of manual aerator speed adjustments would exceed $150,000 annually.

Influent Equalization Process

Prior to equalizing influent flows to the Bardenpho trains, peak flows (about 1.8 times ADF) would cause ammonia breakthrough exceeding 5 mg/L for several hours. The high ammonia levels would persist for another several hours after the peak flow subsided, a condition that was unacceptable for re-rate success.

Implementation of the influent equalization process, for trimming of influent peaks, was just as important for successful re-rating at Iron Bridge as the implementation of supplemental aeration. Permanent plant modifications will include construction of an influent flow equalization process, capable of being operated either in-line or off-line. In the interim, staff converted existing tankage to accomplish equalization of the influent flows applied to the Bardenpho trains.

Flow equalization allows each Bardenpho train to comfortably treat at least 10 mgd without troublesome breakthrough of ammonia during the high-flow periods.

Additional Process Upgrades and Modifications

Additional modifications have been, or will be, implemented at the Iron Bridge facility, including: 1) new pumps and VFDs for the master pump station, 2) new step screens for debris removal, 3) new mixers for fermentation, 4) new pumps and VFDs for internal recyle pumping, 5) new blowers and fine-bubble diffused aeration systems for the Carrousel aeration tanks, 6) new RAS and WAS pumps, VFDs and system controls, 7) retrofit suction-tube secondary clarifiers with energy dissipating inlets and spiral scrapers, and 8) additional deep-bed effluent filters.

Conclusions

As a result of the modifications planned and implemented at the Iron Bridge Bardenpho process, the city of Orlando has made an excellent process (Bardenpho) even better. It is anticipated that this work will result in savings exceeding $40 million dollars through the rerating of the existing Bardenpho trains, as opposed to traditional construction of new tankage and support facilities.