Howard F. Curren Advanced Wastewater Treatment Plant Nitrification Reactor Air Distribution System Improvements

Phase 1 – Study Report






TETRA TECH

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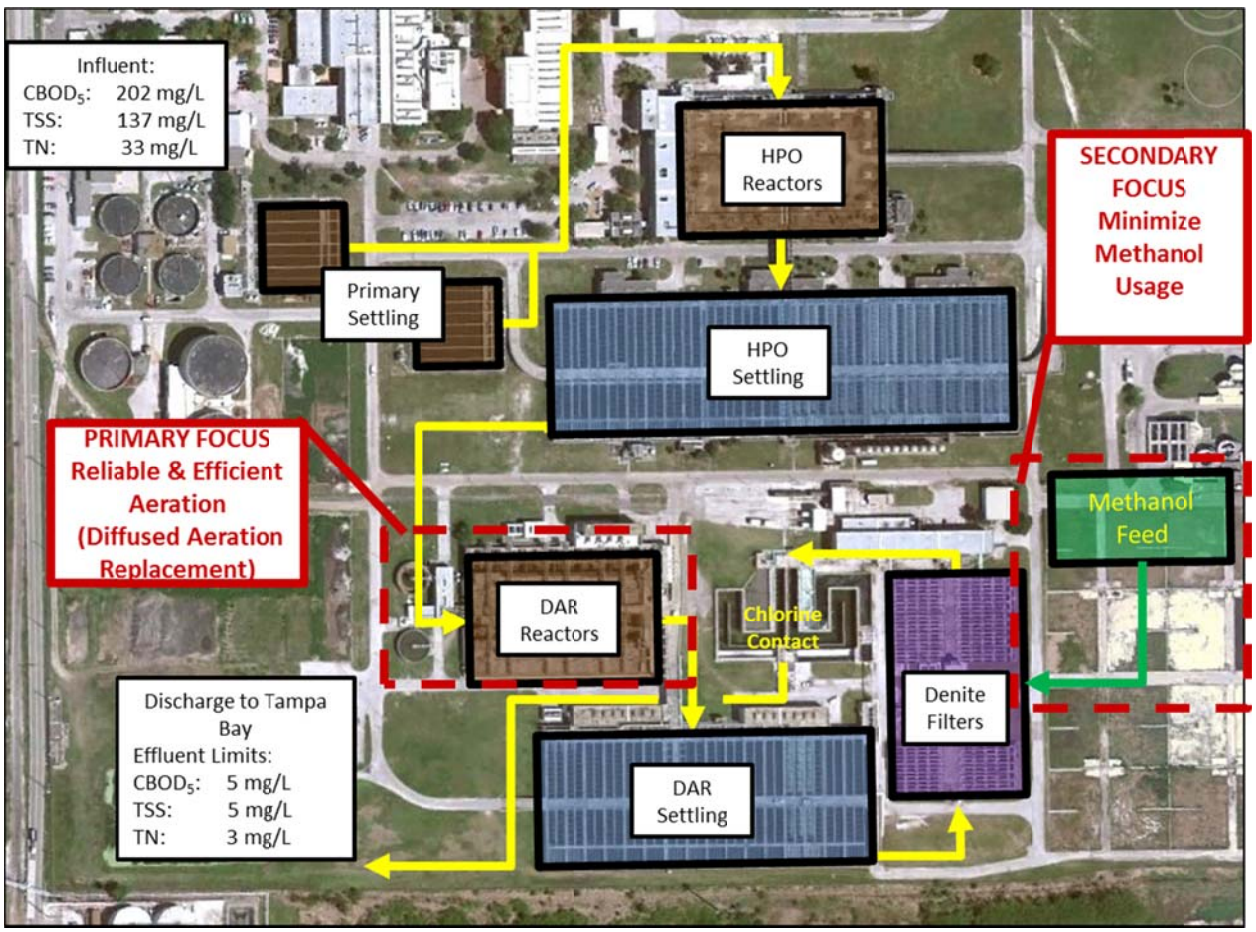
Executive Summary

Tetra Tech, Inc. (Tetra Tech) was authorized by the City of Tampa (City) to conduct a Study of improvements to the City's Howard F. Curren Advanced Wastewater Treatment Plant Nitrification Reactor Air Distribution System. The work as part of this project includes improving the air distribution system in the Nitrification Reactors (also known as the Diffused Air Reactors – DARs), improving the operating efficiency of the reactors, and improving the ability of the system to provide other methods of treatment. There are four (4) DARs (Trains 1 through 4) at the plant. Each DAR is divided into 6 zones (Zones 1 through 6) and each zone is currently equipped with fine bubble membrane disc diffusers. This Study is Phase 1 of the project. Phase 2 of the project is the design, permitting, and construction of the improvements to DAR Train 1. Subsequent phases include the design, permitting and construction of the DAR Trains 2, 3, and 4.

The Howard F. Curren Advanced Wastewater Treatment Plant (HFCAWTP) has a permitted capacity of 96 million gallons per day (MGD) on an average annual daily flow (AADF) basis. The current AADF is approximately 56 MGD and the facility maintains consistent compliance with regulatory agency permit requirements related to effluent quality. Figure ES-1 presents the overall process schematic for the treatment facility which in general includes preliminary treatment followed by primary sedimentation, two-stage activated sludge, denitrification filters, disinfection, solids digestion, and biosolids dewatering. This Study focuses on the second stage of the two-stage activated sludge system, the Diffused Air Reactors (DARs).

Figure ES-1
Overall Process Schematic of HFCAWTP



The first stage of the activated sludge system includes 6 high-rate activated sludge reactors that use High Purity Oxygen (HPO) for removal of carbonaceous biochemical oxygen demand (CBOD). These reactors are referred to as the HPO reactors throughout this study. Each HPO reactor has four zones, each with a mechanical aerator to mix the basin and facilitate oxygen transfer. The HPO reactors are followed by 12 rectangular clarifiers. HPO is generated on-site cryogenically using either a 60 ton per day (tpd) or an 80 tpd generating unit. The second stage of the activated sludge uses four (4) Diffused Air Reactors (DARs) which are mainly used for nitrification. Each DAR is divided into 6 zones (Zones 1 through 6), each currently equipped with fine bubble membrane disc diffusers. Air is delivered to the diffusers by multi-stage centrifugal blowers. There is a spike line from the Main Pumping Station (MPS) to the DARs that allows for a portion of the primary effluent to bypass the HPO reactors. The current AADF at the HFCAWTP is approximately 56 MGD which means the plant is operating at about 59% of the rated capacity. While the facility is operated at lower flows and loadings than the design capacity, there is potential to optimize the operation to minimize operations costs.

The diffusers in the DAR basins have reached the end of their useful life and the design for replacement of these diffusers will occur in Phase 2 of this project. This Phase 1 Study presents the findings from the evaluation of the aeration system replacement alternatives, the wastewater process modeling, and the preliminary opinion of construction costs associated with the improvements to the DARs and associated electrical and instrumentation and controls.

Tetra Tech completed two (2) Technical Memorandums (see appendices) as part of this Phase 1 Study, including:

1. Technical Memorandum No. 1 – Howard F. Curren Advanced Wastewater Treatment Plant Diffused Aeration System Replacement Alternatives (March 6th, 2013).
2. Technical Memorandum No. 2 – Howard F. Curren Advanced Wastewater Treatment Plant Diffused Air Reactor Diffuser Replacement Modeling Report (March 7th, 2014)

As presented in Technical Memorandum No. 1 (Tech Memo 1), several different types of aeration floor covering systems (e.g. disc, panel, tubular) are available for the City's consideration. To assist in the evaluation of the different aeration systems, the City and Tetra Tech developed a Request for Information (RFI) that was transmitted to various aeration system vendors. The RFI included a range of criteria for sizing of the aeration equipment and development of budgetary costs. The City's recent Capacity Analysis Report (CAR) was utilized to estimate the projected wastewater flows within the City's service area. The CAR indicates that flows are expected to increase by about 0.9 MGD/year for the next few years. The flows and average daily DAR oxygen requirements were projected for the next 20 years. In addition, the manufacturers were advised that the floor cover system for the first three (3) zones of each DAR should be compatible with submersible mixers sized for an intensity of 25 horsepower (hp)/million gallons. The manufacturers provided detailed proposals that resulted in a total of eight (8) feasible options, including the following:

- Aquarius Disc Membranes (standard density)
- Aquarius Disc Membranes (high efficiency)
- SSI Disc Membranes
- Sanitaire Disc Membranes
- Sanitaire Panel & Disc Membrane Combination
- OTT Tubular Membranes
- Ovivo Membrane Panels
- Parkson Membrane Panels

The information from the manufacturers and the budgetary 20-year present worth cost for replacing the floor cover system in all four DARs (DAR 1 through 4) is detailed in Appendix A (Technical Memorandum No. 1 – HFCAWTP Diffused Aeration System Replacement Alternatives) and is summarized as follows in Table ES-1:

Table ES-1
Diffused Aeration Equipment Budgetary 20-Year Present Worth Costs
Diffused Air Reactors – All 4 Trains

Manufacturer	Aquarius Standard Efficiency	Aquarius High Efficiency	SSI	Sanitaire	Sanitaire	OTT	Aerostrip	Parkson
Type	Disc	Disc	Disc	Disc	Panel & Disc	Tubular	Panel	Panel
Capital Cost	$775,000	$910,000	$1,289,000	$761,000	$1,257,000	$889,000	$1,362,000	$1,263,000
Present Worth of Power Cost	$4,252,000	$3,929,000	$4,011,000	$4,434,000	$3,477,000	$3,881,000	$3,905,000	$5,076,000
Present Worth of Membrane Replacement	$38,000	$57,000	$33,000	$46,000	$138,000	$76,000	$261,000	$359,000
Total 20-Year Present Worth	**$5,065,000**	**$4,896,000**	**$5,333,000**	**$5,241,000**	**$4,872,000**	**$4,846,000**	**$5,528,000**	**$6,698,000**

Notes:

A. Power costs based on performance curves for the existing blowers and a unit cost for energy of $0.08/kWh.
B. Present worth values based on an interest rate of 6.0%.

Technical Memorandum No. 2 (Tech Memo 2) presents the results from the GPS-X® modeling. Tetra Tech's modeling effort included:

1. Calibration of the GPS-X model (model provided by the City).
2. Performing modeling using 24-hour composite data provided by the City:
   a. Conducted modeling focused on optimization of DARs operation.
   b. Conducted modeling focused on combined optimization of HPO (high purity oxygen) reactors and DARs.
3. Performing modeling of DARs operation using updated grab samples and ChemScan® data.

Tetra Tech originally modeled denitrification performance and oxygen demand at the DARs based in part on 24-hour composite data provided by the City that indicated a significant quantity of nitrification at the HPO reactors. Plant staff later indicated that the HPO effluent NOx-N concentrations are not as high or corresponding NH_3-N and TKN concentrations as low as reported by the daily composite lab data. This is supported by recent grab samples collected at the same location as the composite sampler and by ChemScan® data from just downstream of the composite sample point. The results of the original Tetra Tech process modeling and the updated process modeling are included in Technical Memorandum No. 2 (attached).

Based on these modeling results, City staff have indicated a desire to install new equipment in DAR Train 1, including new diffusers, air flow control equipment, automated process control sampling/monitoring points, internal recycle, and mixing components. This will allow DAR Train 1 to be operated in a variety of modes to demonstrate the denitrification potential before converting DARs Trains 2, 3, and 4. In order to properly size the aeration equipment for the demonstration basin upgrade of DAR Train 1, the process model was recalibrated to better agree with the grab sample data that City staff support as the more reliable data to utilize in the modeling.

The City has established the following goals for the design of the diffuser replacement for the DARs:

1. The diffusers should use a tapered design to more closely match the oxygen demand profile through the reactors and to maximize oxygen transfer efficiency.

2. The diffuser design should be capable of providing sufficient aeration to meet the air demand at the DARs without denitrification in the DARs.

3. The diffusers should not be negatively affected by periods of non-aeration such that anoxic conditions can be created to allow denitrification at the DARs.

4. DAR aeration system sizing should consider the full range of potential aeration demands for each zone, including from 57 MGD with denitrification to 96 MGD without denitrification.

5. The effluent ammonia and TKN from the DARs shall not exceed 0.8 and 2.0 mg/L, respectively.

Table ES-2 shows the recommended oxygen demands for use in the diffused aeration system design in DAR Train 1. In order to ensure that the current rated capacity of the plant is maintained, diffusers should be installed in Zones 1 and 2 to meet the maximum actual oxygen required (AOR) shown below. These numbers are based on the steady state 96 MGD case at worst case month conditions with all DAR zones fully aerated. The maximum design oxygen demands for Zones 3 through 6 are based on Zones 1 and 2 being operated as anoxic at 67 MGD AADF under the worst case conditions. At higher flows it may be necessary to aerate either one or two of the first two DAR zones under high loadings and cooler temperatures. The minimum oxygen demand case is based on the current flow, with average loading and high temperatures and only DAR 1 in denitrification mode. The average oxygen demand is based on annual average loading conditions at 67 MGD and warm water temperatures. The total AOR is taken from the diurnal modeling for the minimum and average cases and from the steady state modeling for the maximum case.

Table ES-2
Air Demands Recommended for Basis of Design of DAR Train 1

Design Basis	Total AOR	AOR by Zone, lbs/day					
	lbs/day	1	2	3	4	5	6
Minimum	54,499	0	0	6,691	2,769	1,379	1,183
Average	79,533	0	0	8,749	5,873	3,352	1,910
Maximum	132,961	12,091	10,602	9,877	8,721	7,596	5,410

Phase 2 of this project includes the following elements:

1. The design of the complete diffuser replacement system for DAR Train 1. The design will include the following components:
    a. Diffusers
    b. Mixers
    c. Piping
    d. Automated Sampling/Process Control Points
    e. Internal Recycle
    f. Programming
2. Permitting and construction of the DAR Train 1 improvements.

3. Optimization of DAR Train 1 nitrification/denitrification process.
4. The evaluation of future upgrades to DARs Trains 2, 3, and 4.

The budgetary cost opinion for completing the improvements to DAR Train 1 are as follows:

Table ES-3
DARs Train 1 Diffused Aeration Equipment Replacement/Process Optimization
Budgetary Cost Opinion

Manufacturer	Aquarius Standard Efficiency	Aquarius High Efficiency	SSI	Sanitaire	Sanitaire	OTT	Aerostrip	Parkson
Type	Disc	Disc	Disc	Disc	Panel & Disc	Tubular	Panel	Panel
Train 1 Floor Covering Capital Cost	$260,000	$310,000	$430,000	$260,000	$420,000	$300,000	$460,000	$425,000
Electrical/I&C Equipment	$90,000	$90,000	$90,000	$90,000	$90,000	$90,000	$90,000	$90,000
Engineering, Permitting, Construction Admin	$215,000	$215,000	$215,000	$215,000	$215,000	$215,000	$215,000	$215,000
Subtotal	$565,000	$615,000	$735,000	$565,000	$725,000	$605,000	$765,000	$730,000
Contingency (20%)	$113,000	$123,000	$147,000	$113,000	$145,000	$121,000	$153,000	$146,000
Budgetary Cost	**$678,000**	**$738,000**	**$882,000**	**$678,000**	**$870,000**	**$726,000**	**$918,000**	**$876,000**

As shown in Table ES-3, the improvements included in the Train 1 upgrades are at a minimum:

- New aeration system floor covering (including piping) in all 6 zones of Train 1
- New electrical/I&C associated with the Train 1 aeration system upgrades and process optimization (including automation of air delivery valves)
- Engineering, permitting, and construction administration for the Train 1 upgrades

Currently, there are ongoing discussions with the City's staff regarding the replacement or addition of the following equipment to improve operation and denitrification ability of the DARs:

- Mixers – (replacement)
- Internal Recycle Pumps/Piping – (addition)
- Jockey Air Blower(s) – (addition)

The details of this equipment, as well as the associated costs, will be presented in the Preliminary Design Report developed in Phase 2 of this project. Currently, replacement of any of the four (4) existing multi-stage, 700 HP centrifugal air blowers is not included in this project.

During Phase 2 of this project, the engineer's opinion of construction cost will be developed during the preliminary and final design process and will include costs for all of the equipment identified in the Preliminary Design Report.

In summary, the following key points have been identified as part of this Phase 1 – Study Report effort:

1. The GPS-X modeling results presented in Technical Memorandum No. 2 indicate that at HFCAWTP's current average flow, the cost savings in reduced methanol use will exceed $500,000 per year.
2. The City is currently achieving denitrification within the existing DARs with on-off aeration operation and has calculated a realized cost savings greater than $500,000 per year due to the reduction in methanol use in the denitrification filters.
3. As wastewater flows to the HFCAWTP approach the rated plant capacity, less denitrification will occur in the DARs.
4. The panel-type diffuser is an efficient aeration delivery system with potential for less ragging and less intensive maintenance requirements. The City is moving forward with installing this diffuser type in DAR Train 1, monitoring the performance of these panel diffusers, and then confirming the diffuser type that will be selected to replace the diffusers in DARs Trains 2, 3, and 4.
5. The City will monitor the performance of the existing four (4) existing multi-stage, 700 HP centrifugal air blowers and determine when these blowers should be replaced.

The City's proactive approach to optimizing the HFCAWTP's treatment process will continue to afford the City overall process and energy cost savings in the operation of this facility.

Section 1.0 Introduction

The City's Howard F. Curren Advanced Wastewater Treatment Plant (HFCAWTP) has a permitted design capacity of 96 million gallons per day (MGD) on an average annual daily flow (AADF) basis. The current AADF is approximately 56 MGD and the facility maintains consistent compliance with regulatory agency permit requirements related to effluent quality. Figure 1-1 presents an overall process schematic of the HFCAWTP.

As shown in Figure 1-1, the facility features a two-stage aerobic treatment process. The first stage of treatment involves mainly removal of carbonaceous biochemical oxygen demand ($CBOD_5$) although the operating data indicates a smaller but significant amount of nitrification. The second stage of treatment provides nitrification within Diffused Air Reactors (DARs) via a suspended growth activated sludge process that includes a conventional fine pore diffused aeration system. The DAR structure includes four (4) parallel process trains that are divided into six (6) zones per train. The diffused aeration system has been in service for approximately 20 years and is approaching the end of its useful life. Tetra Tech evaluated various types of diffused aeration technologies that could be considered for replacing the existing system. The results from the evaluation of eight (8) diffused aeration systems are presented in Appendix A as Technical Memorandum No. 1 – Howard F. Curren Advanced Wastewater Treatment Plant Diffused Aeration System Replacement Alternatives.

Additionally, Tetra Tech conducted wastewater process modeling using the City's GPS-X® model to evaluate the two-stage activated sludge process. The City established the following goals for the design of the diffuser replacement for the DARs:

1. The diffusers should use a tapered design to more closely match the oxygen demand profile through the reactors and to maximize oxygen transfer efficiency.

2. The diffuser design should be capable of providing sufficient aeration to meet the air demand at the DARs without any denitrification in the DARs and without any nitrification in the HPO basins.

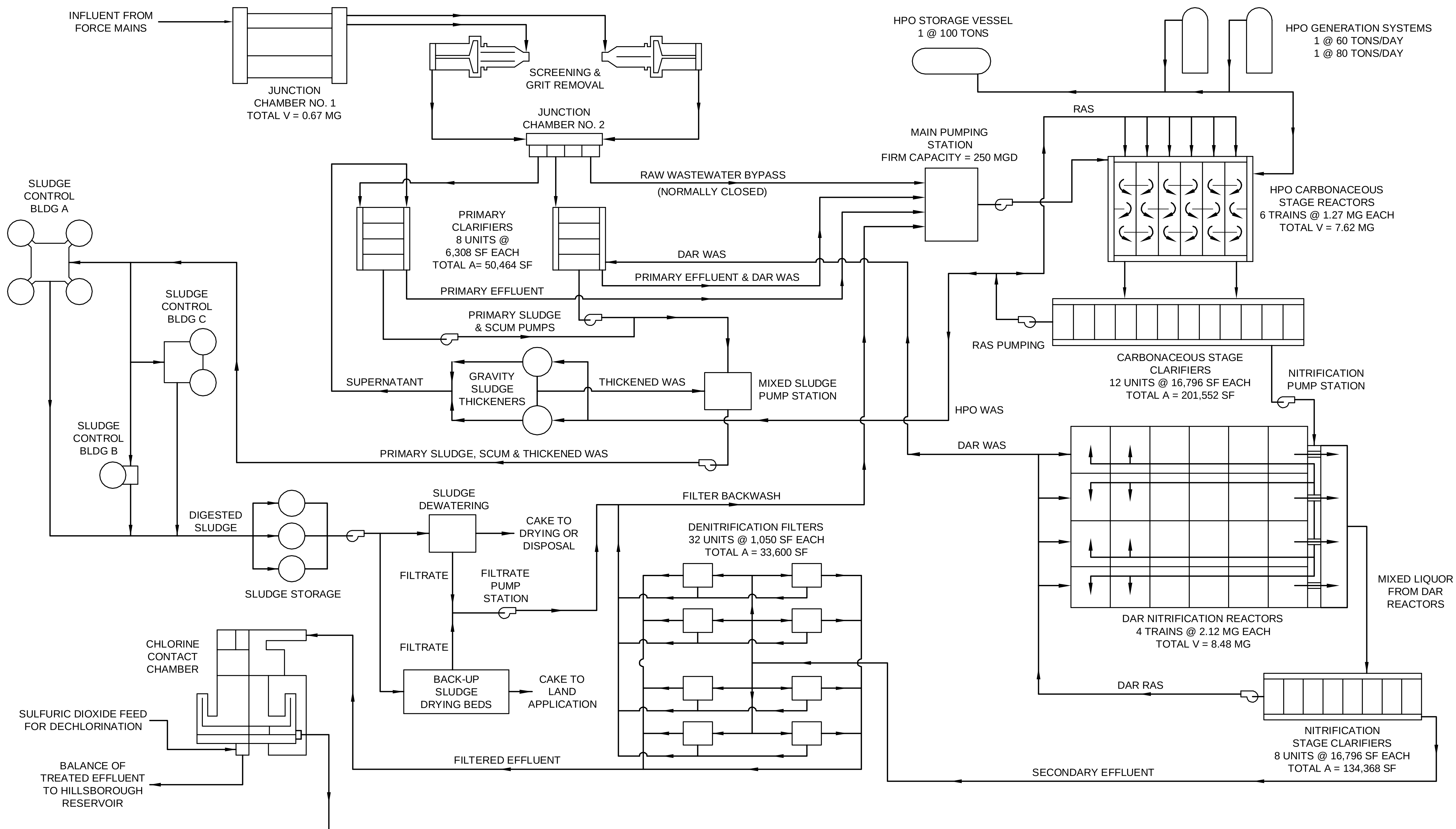
3. The diffusers should not be negatively affected by periods of non-aeration so that anoxic conditions can be created to allow denitrification at the DARs.

4. The DAR diffuser system is to maintain efficient operation in the event operational changes are made at the HPO reactors.

5. The effluent ammonia and TKN from the DARs should not exceed 0.8 and 2.0 mg/L respectively.

6. Operation of the DARs will be optimized to achieve more denitrification within the DARs basins, allowing for reduced methanol use in the denitrification filters and a methanol cost savings.

Tetra Tech formulated and modeled different operational scenarios that vary the oxygen demand distribution and the degree of denitrification. The diffuser design will be based on information from all of these scenarios to provide the flexibility necessary to maintain efficient operation over a range of operational strategies. The results from the wastewater process modeling are presented in Appendix B as Technical Memorandum No. 2 – Howard F. Curren Advanced Wastewater Treatment Plant Diffused Air Reactor Diffuser Replacement Modeling Report.



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CITY OF TAMPA, FLORIDA

PROCESS OPTIMIZATION FEASABILITY STUDY
HOWARD F. CURREN AWTP

SIMPLIFIED PROCESS FLOW SCHEMATIC

Project No.:	200-08494-09001
Date:	5/2010
Designed By:	SGN
FIGURE	1

Section 2.0 Air Distribution System Evaluation

The results from the evaluation of eight (8) diffused aeration systems are presented in Appendix A as Technical Memorandum No. 1 – Howard F. Curren Advanced Wastewater Treatment Plant Diffused Aeration System Replacement Alternatives. For the evaluation, the following determinations were made:

- Current and projected oxygen requirements to satisfy process demands for next 20 years
- Equipment options (e.g. discs, tubular membranes, membrane panels)
- Projected oxygen demand distribution in each zone of each DAR basin

To determine the amount of oxygen needed to satisfy the process demands, a detailed examination of flows, influent characteristics, mass loadings, and performance data was completed in conjunction with the extensive wastewater process modeling to estimate average and maximum day oxygen requirements at both current flows and at the rated plant capacity of 96 MGD.

The City's recent Capacity Analysis Report (CAR) was utilized to estimate the projected wastewater flows within the City's service area. The CAR indicates that flows are expected to increase by about 0.9 MGD/year for the next few years. The flows and average daily DAR oxygen requirements were projected for the next 20 years.

To assist in the evaluation of the different aeration systems, the City and Tetra Tech developed a Request for Information (RFI) that was transmitted to various aeration system vendors. The RFI included a range of criteria for sizing of the aeration equipment and development of budgetary costs.

In addition to the stated criteria, the manufacturers were advised that the floor cover system for the first three (3) zones of each DAR should be compatible with submersible mixers sized for an intensity of 25 horsepower (hp)/million gallons. The manufacturers provided detailed proposals that resulted in a total of eight (8) feasible options, including the following:

- Aquarius Disc Membranes (standard density)
- Aquarius Disc Membranes (high efficiency)
- SSI Disc Membranes
- Sanitaire Disc Membranes
- Sanitaire Panel & Disc Membrane Combination
- OTT Tubular Membranes
- Ovivo Membrane Panels
- Parkson Membrane Panels

The information from the manufacturers and the budgetary 20-year present worth cost for replacing the floor cover system in all four DARs (DARs 1 through 4) is detailed in Appendix A (Technical Memorandum No. 1 – Howard F. Curren Advanced Wastewater Treatment Plant Diffused Aeration System Replacement Alternatives) and is summarized as follows in Table 2-1:

Table 2-1. Diffused Aeration Equipment Budgetary 20-Year Present Worth Costs
Diffused Air Reactors – All 4 Trains

Manufacturer	Aquarius Standard Efficiency	Aquarius High Efficiency	SSI	Sanitaire	Sanitaire	OTT	Aerostrip	Parkson
Type	Disc	Disc	Disc	Disc	Panel & Disc	Tubular	Panel	Panel
Capital Cost	$775,000	$910,000	$1,289,000	$761,000	$1,257,000	$889,000	$1,362,000	$1,263,000
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Present Worth of Membrane Replacement	$38,000	$57,000	$33,000	$46,000	$138,000	$76,000	$261,000	$359,000
Total 20-Year Present Worth	**$5,065,000**	**$4,896,000**	**$5,333,000**	**$5,241,000**	**$4,872,000**	**$4,846,000**	**$5,528,000**	**$6,698,000**

Notes:

A. Power costs based on performance curves for the existing blowers and a unit cost for energy of $0.08/kWh.
B. Present worth values based on an interest rate of 6.0%.

The City's staff observed diffused aeration equipment in operation at local wastewater treatment facilities. Site visits of two (2) wastewater treatment facilities were conducted on July 17th, 2013 so that the City staff could become more familiar with the operation of the tubular and panel diffused aeration system equipment. City staff visited one wastewater treatment facility that operates a tubular membrane system and visited another wastewater treatment facility that operates a membrane panel system. These site visits allowed the City's staff to view the equipment in operation and discuss the operation of the equipment with the operators of these wastewater treatment facilities.

The City is moving forward with installing the panel-type diffuser in DAR Train 1. The panel-type diffuser is an efficient aeration delivery system with potential for less ragging and less intensive maintenance requirements. The City will monitor the performance of these panel diffusers in DAR Train 1 and then confirm the diffuser type that will be selected to replace the diffusers in DARs Trains 2, 3, and 4.

Section 3.0 Wastewater Process Modeling

Technical Memorandum No. 2 (Tech Memo 2) in Appendix B presents the results from the GPS-X® modeling. Tetra Tech's modeling effort included:

1. Calibration of the GPS-X model (model provided by the City).
2. Performing modeling using 24-hour composite data provided by the City:
    a. Conducted modeling focused on optimization of DARs operation.
    b. Conducted modeling focused on combined optimization of HPO (high purity oxygen) reactors and DARs.
3. Performing modeling of DARs operation using updated grab samples and ChemScan® data.

Tetra Tech originally modeled denitrification performance and oxygen demand at the DARs based in part on 24-hour composite data provided by the City that indicated a significant quantity of nitrification at the HPO reactors. Plant staff later indicated that the HPO effluent NOx-N concentrations are not as high or corresponding NH_3-N and TKN concentrations as low as reported by the daily composite lab data. This is supported by recent grab samples collected at the same location as the composite sampler and by ChemScan® data from just downstream of the composite sample point. As a result of these differences, additional modeling was performed based on the grab sample data. The results of the original Tetra Tech process modeling and the updated process modeling are included in Technical Memorandum No. 2 (attached).

Based on these modeling results, City staff have indicated a desire to install new diffusers, mixers, air flow control equipment, and internal recycle in DAR Train 1 so that Train 1 can be operated in a variety of modes to demonstrate the denitrification potential before converting the other DARs. In order to properly size the aeration equipment for the demonstration basin upgrade of DAR Train 1, the process model was recalibrated to better agree with the grab sample data that City staff support as the more reliable data to utilize in the modeling.

The City has established the following goals for the design of the diffuser replacement for the DARs:

1. The diffusers should use a tapered design to more closely match the oxygen demand profile through the reactors and to maximize oxygen transfer efficiency.

2. The diffuser design should be capable of providing sufficient aeration to meet the air demand at the DARs without denitrification in the DARs.

3. The diffusers should not be negatively affected by periods of non-aeration such that anoxic conditions can be created to allow denitrification at the DARs.

4. DAR aeration system sizing should consider the full range of potential aeration demands for each zone, including from 57 MGD with denitrification to 96 MGD without denitrification.

5. The effluent ammonia and TKN from the DARs shall not exceed 0.8 and 2.0 mg/L, respectively.

Table 3-1 shows the recommended oxygen demands for use in the diffused aeration system design in DAR Train 1. In order to ensure that the current rated capacity of the plant is maintained, diffusers should be installed in Zones 1 and 2 to meet the maximum actually oxygen required (AOR) shown below. These numbers are based on the steady state 96 MGD case at worst case month conditions with all DAR zones fully aerated. The maximum design oxygen demands for Zones 3 through 6 are based on Zones 1 and 2 being operated as anoxic at 67 MGD AADF under the worst case conditions. At higher flows it may be necessary to aerate either one or two of the first two DAR zones under high loadings and cooler temperatures. The minimum oxygen demand case is based on the current flow, with average loading and high temperatures and only DAR 1 in denitrification mode. The average oxygen demand is based on annual average loading conditions at 67 MGD and warm water temperatures. The total AOR is taken from the diurnal modeling for the minimum and average cases and from the steady state modeling for the maximum case.

Table 3-1
Air Demands Recommended for Basis of Design of DAR Train 1

Design Basis	Total AOR	AOR by Zone, lbs/day					
	lbs/day	1	2	3	4	5	6
Minimum	54,499	0	0	6,691	2,769	1,379	1,183
Average	79,533	0	0	8,749	5,873	3,352	1,910
Maximum	132,961	12,091	10,602	9,877	8,721	7,596	5,410

Section 4.0 DARs Instrumentation and Controls Conceptual Design

Proposed upgrades to the existing Diffused Air Reactors (DARs) include upgrades to the existing instrumentation and controls (I&C) systems. As presented previously, there are four (4) DAR basins and each basin has six (6) aeration zones. Currently, air flow to these zones is controlled with manual valves. As part of the on/off air strategy for the DARs, it is recommended that the air system controls be upgraded and that air flow to the first five (5) zones in each DAR basin be controlled by a motor-operated butterfly valve. During the preliminary design of Phase 2 of this project, it will be determined if air flow to the last zone (Zone 6) should be controlled by a motor-operated butterfly valve. The existing butterfly valves on the intake side of the blowers and the butterfly valves at the DAR basin can be equipped with modulating actuator to achieve this function. This will allow for advanced air flow control and reduced operator hours to implement the on/off air strategy. It is proposed that the Zone 6 air flow valves be manually controlled in each basin as it is has been determined that, in general, this zone will normally operate with the air always on prior to the water entering the denitrification basins.

The instruments to be utilized at the DAR basins for the on/off air flow strategy include both air flow control meters and probes to monitor oxygen and ammonia in the basins. The proposed instruments include, but will not be limited to, the following:

- Air mass flow meters
- Optical type DO (dissolved oxygen) probes
- ORP (oxidation reduction potential) probes
- Ammonia probes using ion selective electrodes

Automated monitoring and control of the instruments is proposed to occur with a local programmable logic controller (PLC) with additional capability for the City's staff to modify setpoints through the Curren AWTP's supervisory control and data acquisition (SCADA) system. Control logic will be included to adjust duration of aeration cycles and air flow during aeration cycles.

Aeration Cycle Duration

Plant operators will have the capability to adjust the duration of the aeration cycles so that the nitrification/denitrification process in the DARs can be optimized for maximum nutrient removal. The conceptual design for the aeration cycle duration includes four (4) operator selectable modes to control duration of air on (valve open) and air off (valve closed) periods. These modes include:

- Continuous aeration
- Duration in hours (i.e. 4 hrs on/4 hours off in a repeating cycle)
- ORP setpoint in mV
- Ammonia concentration setpoint in mg/L

Aeration Cycle Air Flow

The volume of air delivered to each zone of each DAR basin during the "air on" period will be controlled with the position of the air flow control valves. These valves will be positioned by using one of five (5) operator selectable modes:

- Position setpoint (% open)
- Air flow setpoint (scfm)
- DO setpoint (mg/L)
- ORP setpoint (mg/L)
- Ammonia concentration setpoint (for continuous aeration mode only)

Specific recommendations for air system control and the electrical design associated with the instruments and controls (I&C) for the aeration at the DARs will be presented in Phase 2 - Preliminary Design.

Section 5.0 Budgetary Cost Opinion for Improvements to DARs Train 1

The budget costs estimates for improvements to all four DAR trains (Trains 1 through 4) were presented previously in Section 2.0 and in Tech Memo 1 (Appendix A). The City wishes to proceed with improvements to Train 1 first and then improvements to Trains 2, 3, and 4 upon evaluation of the performance of the aeration equipment in Train 1. Additionally, the City has determined to proceed with the installation of the panel aeration floor covering system in Train 1.

The budgetary cost opinion for completing the improvements to DARs Train 1 are as follows:

Table 5-1
DARs Train 1 Diffused Aeration Equipment Replacement/Process Optimization
Budgetary Cost Opinion

Manufacturer	Aquarius Standard Efficiency	Aquarius High Efficiency	SSI	Sanitaire	Sanitaire	OTT	Aerostrip	Parkson
Type	Disc	Disc	Disc	Disc	Panel & Disc	Tubular	Panel	Panel
Train 1 Floor Covering Capital Cost	$260,000	$310,000	$430,000	$260,000	$420,000	$300,000	$460,000	$425,000
Electrical/I&C Equipment	$90,000	$90,000	$90,000	$90,000	$90,000	$90,000	$90,000	$90,000
Engineering, Permitting, Construction Admin	$215,000	$215,000	$215,000	$215,000	$215,000	$215,000	$215,000	$215,000
Subtotal	$565,000	$615,000	$735,000	$565,000	$725,000	$605,000	$765,000	$730,000
Contingency (20%)	$113,000	$123,000	$147,000	$113,000	$145,000	$121,000	$153,000	$146,000
Budgetary Cost	**$678,000**	**$738,000**	**$882,000**	**$678,000**	**$870,000**	**$726,000**	**$918,000**	**$876,000**

As shown in Table 5-1, the improvements included in the Train 1 upgrades are at a minimum:

- New aeration system floor covering (including piping) in all 6 zones of Train 1
- New electrical/I&C associated with the Train 1 aeration system upgrades and process optimization (including automation of air delivery valves)
- Engineering, permitting, and construction administration for the Train 1 upgrades

Currently, there are ongoing discussions with the City's staff regarding the replacement or addition of the following equipment to improve operation and denitrification ability of the DARs:

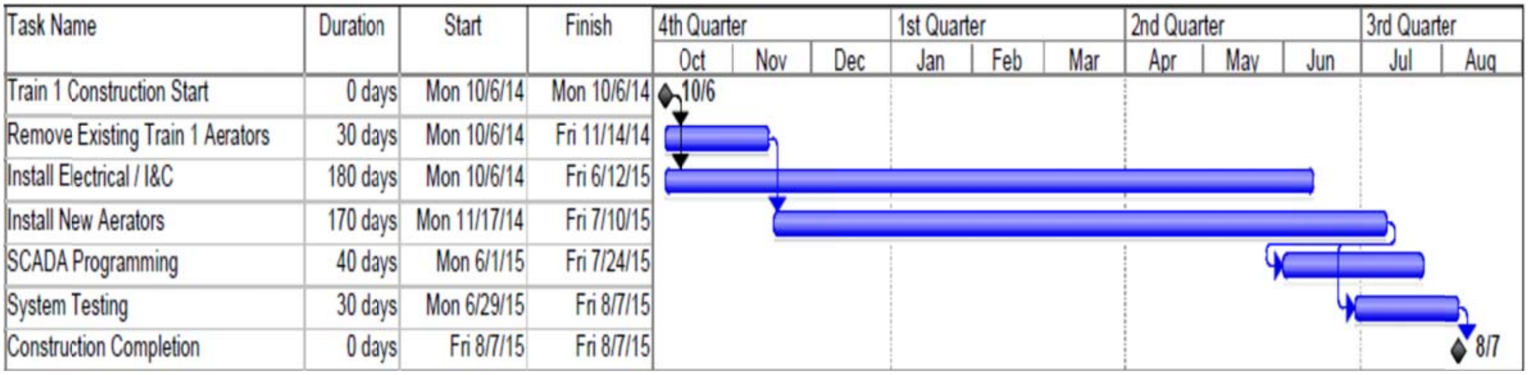
- Mixers – (replacement)
- Internal Recycle Pumps/Piping – (addition)
- Jockey Air Blower(s) – (addition)

The details of this equipment, as well as the associated costs, will be presented in the Preliminary Design Report developed in Phase 2 of this project. Currently, replacement of any of the four (4) existing multi-stage, 700 HP centrifugal air blowers is not included in this project.

During Phase 2 of this project, the engineer's opinion of construction cost will be developed during the preliminary and final design process and will include costs for all of the equipment identified in the Preliminary Design Report.

Section 6.0 Construction Phasing Schedule

It is expected that the construction duration for the replacement of the aeration equipment in Train 1 is approximately 10 months. The proposed construction phasing schedule is as follows:



Task Name	Duration	Start	Finish
Train 1 Construction Start	0 days	Mon 10/6/14	Mon 10/6/14
Remove Existing Train 1 Aerators	30 days	Mon 10/6/14	Fri 11/14/14
Install Electrical / I&C	180 days	Mon 10/6/14	Fri 6/12/15
Install New Aerators	170 days	Mon 11/17/14	Fri 7/10/15
SCADA Programming	40 days	Mon 6/1/15	Fri 7/24/15
System Testing	30 days	Mon 6/29/15	Fri 8/7/15
Construction Completion	0 days	Fri 8/7/15	Fri 8/7/15

Section 7.0 Summary and Recommendations

The City has determined that it will proceed with the following work for improvements in the Diffused Air Reactors (DARs) as part of Phase 2 of this project:

1. Replacement of the diffused aeration system (floor covering and piping) in Train 1 of the DARs with a panel aeration system.
2. Replacement of the mixers in the six (6) basins of Train 1.
3. Automation of sampling/process control points in Train 1.
4. Addition of internal recycle for Train 1.

Train 1 is currently offline and has been offline for approximately 10 years. Upon construction completion of the improvements to Train 1 and operation of Train 1 for approximately six (6) to twelve (12) months, the City will evaluate the operation of Train 1 and the new panel aeration system in Train 1. At the conclusion of that evaluation, the City will determine the next steps for replacement of the aeration systems in Trains 2, 3, and 4.

Phase 2 will include the design (preliminary and final), permitting, and construction of the diffused aeration system in Train 1. During the preliminary design phase, the revised, preliminary layout of the panel aeration system and the preliminary construction costs will be developed using the recommendations for actual oxygen required (AOR) as identified in the updated GPS-X modeling effort. This information will be summarized in the Preliminary Design Report. A panel aeration system layout utilized for the development of budgetary costs is included in Appendix A (Technical Memorandum No. 1 – HFCAWTP Diffused Aeration System Replacement Alternatives) – Attachment F (Ovivo's Aerostrip Q Type Diffuser).

Based on the preliminary design of the panel aeration system, the preliminary design of the following equipment will be developed and presented in the Preliminary Design Report:

1. Mixers
2. Instrumentation & Controls (I&C)
3. Potential "jockey" blower(s) to deliver air for reduced wastewater flow conditions

The results from the GPS-X process modeling are presented in detail in Appendix B (Technical Memorandum No. 2 – HFCAWTP Diffused Air Reactor Diffuser Replacement Modeling Report).

Depending on the evaluation of results from the operation of Train 1, the layout of the aeration floor covering may be further refined for DARs Trains 2, 3, and 4.

In summary, the following key points have been identified as part of this Phase 1 – Study Report effort:

1. The GPS-X modeling results presented in Technical Memorandum No. 2 indicate that at HFCAWTP's current average flow, the cost savings in reduced methanol use will exceed $500,000 per year.
2. The City is currently achieving denitrification within the existing DARs with on-off aeration operation and has calculated a realized cost savings greater than $500,000 per year due to the reduction in methanol use in the denitrification filters.
3. As wastewater flows to the HFCAWTP approach the rated plant capacity, less denitrification will occur in the DARs.
4. The panel-type diffuser is an efficient aeration delivery system with potential for less ragging and less intensive maintenance requirements. The City is moving forward with installing this diffuser type in DAR Train 1, monitoring the performance of these panel diffusers, and then confirming the diffuser type that will be selected to replace the diffusers in DARs Trains 2, 3, and 4.

5. The City will monitor the performance of the existing four (4) existing multi-stage, 700 HP centrifugal air blowers and determine when these blowers should be replaced.

The City’s proactive approach to optimizing the HFCAWTP’s treatment process will continue to afford the City overall process and energy cost savings in the operation of this facility.

Technical Memorandum No. 1

Howard F. Curren Advanced Wastewater Treatment Plant

Diffused Aeration System Replacement Alternatives

TECHNICAL MEMORANDUM

To: Charlie Lynch, P.E.
Rory Jones, E.I.

From: Emilie Moore, P.E., Tetra Tech
John P. Toomey, P.E., Tetra Tech

Re: Technical Memorandum No. 1 - Howard F. Curren Advanced Wastewater Treatment Plant Diffused Aeration System Replacement Alternatives

Date: March 6, 2013

Tt #: 200-08494-12002

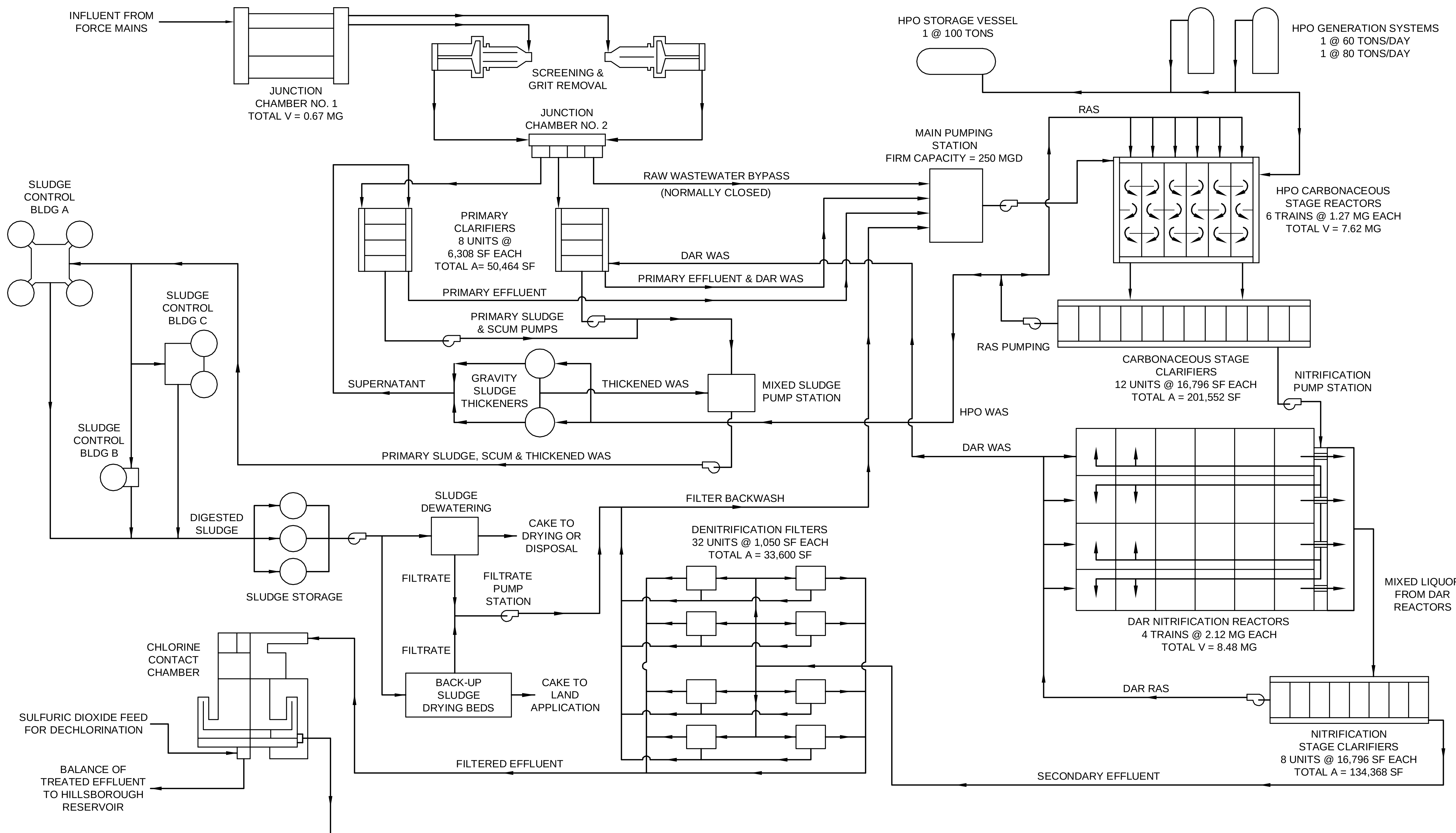
Background, Purpose & Scope

The City of Tampa's Howard F. Curren Advanced Wastewater Treatment Plant (HFCAWT) has a permitted design capacity of 96 million gallons per day (MGD) on an average annual daily flow (AADF) basis. The current AADF is approximately 56 MGD and the facility maintains consistent compliance with regulatory agency permit requirements related to effluent quality. Figure 1 present an overall process schematic of plant for reference.

As shown in Figure 1 the facility features a two-stage aerobic treatment process. The first stage of treatment involves mainly removal of carbonaceous biochemical oxygen demand ($CBOD_5$) although the operating data indicates a smaller but significant amount of nitrification. The second stage of treatment provides nitrification within diffused aeration reactors (DARs) via a suspended growth activated sludge process that includes a conventional fine pore diffused aeration system. The DAR structure includes four parallel process trains that are divided into six zones per train. The diffused aeration system has been in service for approximately 20 years and it is approaching the end of its useful life. In view of this fact, the City has retained Tetra Tech to examine various types of diffused aeration technologies that could be used to replace the existing system. This memorandum presents initial findings, conclusions, and recommendations resulting from the evaluation of eight different equipment replacement options.

Current & Projected Oxygen Requirements

In order to properly evaluate aeration technologies it is necessary to first ascertain the amount of oxygen needed to satisfy the process demands. A detailed examination of flows, influent characteristic, mass loadings, and performance data was completed in conjunction with extensive process modeling to estimate average and maximum day oxygen requirements at both current flows and at the rated plant capacity of 96 MGD. A separate document presents the details associated with this effort. The net oxygen requirements resulting from the modeling work are summarized in Table 1.



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CITY OF TAMPA, FLORIDA

PROCESS OPTIMIZATION FEASABILITY STUDY
HOWARD F. CURREN AWTP

SIMPLIFIED PROCESS FLOW SCHEMATIC

Project No.:	200-08494-09001
Date:	5/2010
Designed By:	SGN
FIGURE	1

Table 1
Summary of DAR Oxygen Requirements at Current Flows & Rated Capacities

Parameter	Current		Future (Rated Capacity)	
	Flow (MGD)	Oxygen Required (lbs/day)	Flow (MGD)	Oxygen Required (lbs/day
Average Daily Condition	56.0	50,000	96.0	70,000
Maximum Daily Condition	100.8	90,000	172.8	126,000

The values presented in the above table show that a 71 percent increase in average daily flow only results in a 40 percent increase in oxygen demand. This result may not be intuitive; however, it is the result of modeling work that takes into account the fact that additional high purity oxygen (HPO) trains would be in operation at the rated capacity. More specifically, running six HPO train at a flow of 96 MGD results in a higher level of nitrification in the initial stage of biological treatment, which decreases the amount of additional oxygen needed in the downstream DAR stage due to increased flow. This issue is discussed in greater detail in a report that addresses the process modeling aspect of this assignment.

In order to evaluate aeration equipment options with respect to energy efficiency, it is necessary to take into account increases in flow that result from growth within the service area. The City's recent Capacity Analysis Report (CAR) indicates that flows are expected to increase by about 0.9 MGD/year for the next few years. This rate of growth seems somewhat large considering the current economic environment; however, this rate will generate reasonable flow projections that can be used to estimate oxygen demands and power cost estimates. Table 2, below, presents projected flows and average daily DAR oxygen requirements for the next 20 years.

Table 2
Projected Flows & Oxygen Requirements for 20-Year Study Period

Year	Average Daily Flow (MGD)	Average Oxygen Requirement (lbs/day)
2013	56.0	50,000
2014	56.9	50,804
2015	57.8	51,607
2016	58.7	52,411
2017	59.6	53,214
2018	60.5	54,018
2019	61.4	54,821
2020	62.3	55,625
2021	63.2	56,429
2022	64.1	57,232
2023	65.0	58,036
2024	65.9	58,839
2025	66.8	59,643
2026	67.7	60,446
2027	68.6	61,250

Table 2 (Cont'd.)
Projected Flows & Oxygen Requirements for 20-Year Study Period

Year	Average Daily Flow (MGD)	Average Oxygen Requirement (lbs/day)
2028	69.5	62,054
2029	70.4	62,857
2030	71.3	63,661
2031	72.2	64,464
2032	73.1	65,268

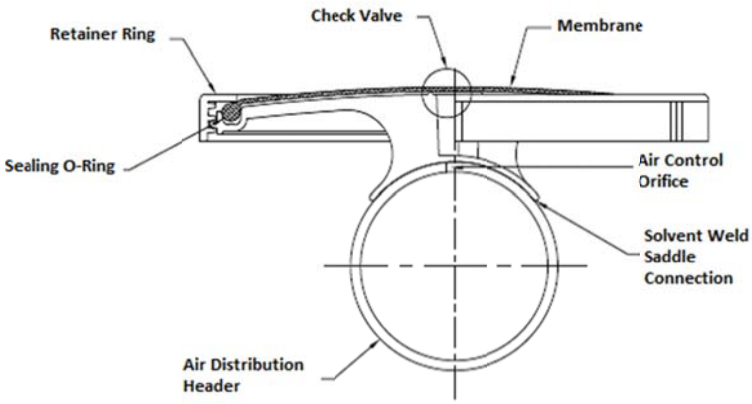
The oxygen requirement presented above for 2013 is based on detailed modeling as discussed above; however, the requirements for subsequent years are simply linear extrapolations based on the projected flow. As previously stated, additional HPO reactors will be placed into operation which will increase nitrification in the first stage, which in turn, will mitigate the need for additional oxygen in the DAR stage. It is beyond the scope of this assignment to perform modeling for each year of the 20-year study period; therefore, simple linear extrapolation has been used to give approximate, yet conservative, oxygen requirements that can be used in an economic analysis.

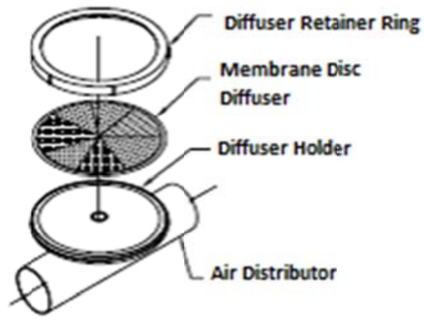
Equipment Options

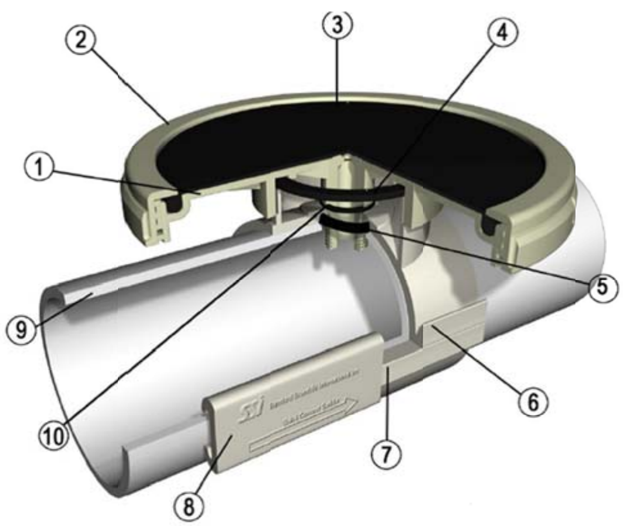
Large WWTPs have oxygen demands that result in significant air requirements and power costs. In order to minimize operating expenditures for energy, high-efficiency oxygen transfer devices are usually employed. The most common type of diffused aeration technology for this application features centrifugal blowers and fine-pore membrane air diffusion devices. The diffuser membranes are usually manufactured from EPDM or polyurethane and configured as discs, tubes or panels. Additional descriptions of the various diffuser equipment options are presented below.

Discs: The most common high-efficiency membrane system involves a 9-inch diameter disc installed in a PVC or polyurethane holder that includes a removable retaining ring which allows disc removal and replacement. These units are offered by Aquarius Technologies, Stamford Scientific International (SSI), and Sanitaire.

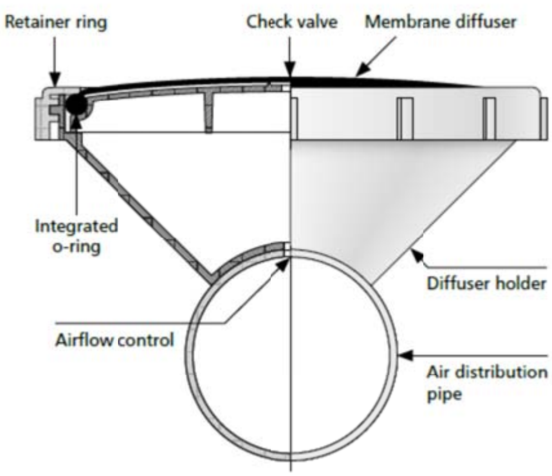
The Aquarius diffuser features a PVC holder that is attached to the floor cover piping via solvent and sonic welding. The manufacturer claims that this method of securing the holder is stronger than the pipe itself. A threaded retaining ring is used to hold the membrane in place and it appears that this system facilitates easy replacement of the membrane. SSI offers a very similar membrane disc diffuser; however, the SSI unit uses a polypropylene pipe saddle and a threaded connection for the diffuser holder. This product also includes a threaded retaining ring to facilitate membrane replacement. The third major type of 9-inch membrane disc diffuser is manufactured by Sanitaire and it is generally known as the Silver Series II. It is very similar in design to the Aquarius product and features a solvent welded membrane holder and threaded retaining ring. Figure 1 presents cut-way views of the three versions of 9-inch disc diffusers under consideration.







	Description	Material
1	Base plate	PP (Polypropylene)
2	Retainer ring	PP (Polypropylene)
3	Membrane	EPDM / PTFE / fEPDM™ / Viton
4	Ø3⅜" Gasket	EPDM
5	Ø1¾" (I.D) x Ø2⅛" (O.D) 3D O-ring	EPDM
6	QC Upper saddle	PP (Polypropylene)
7	QC Lower saddle (QCS 4")	PP
8	QC Wedge	PP (Polypropylene)
9	4½" Pipe (O.D)	
10	1" O-ring	EPDM



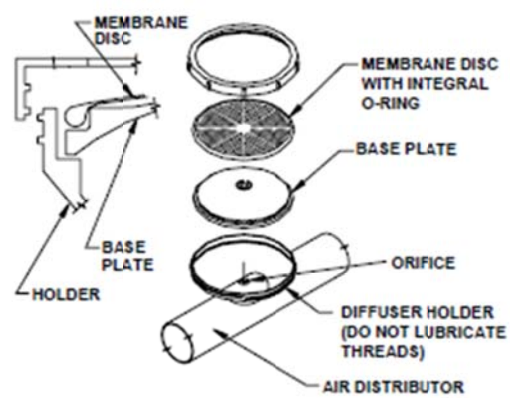


Figure 1
9" Membrane Disc Diffusers by Aquarius, SSS, and Sanitaire

Tubular Membranes: Instead of using flat circular discs to disperse process air, tubular membranes can be attached to cylindrical membrane holders. Typically, tubular diffusers have high unit air flow capacities when compared to discs; therefore, fewer assemblies are needed for a given particular demand. EDI, SSI and OTT manufacture tubular membrane diffusers. The City has expressed interest in evaluating the product offered by OTT. This interest is primarily due to the ease of diffuser replacement that is provided by the system. Figure 2, below, presents an illustration of the OTT system.

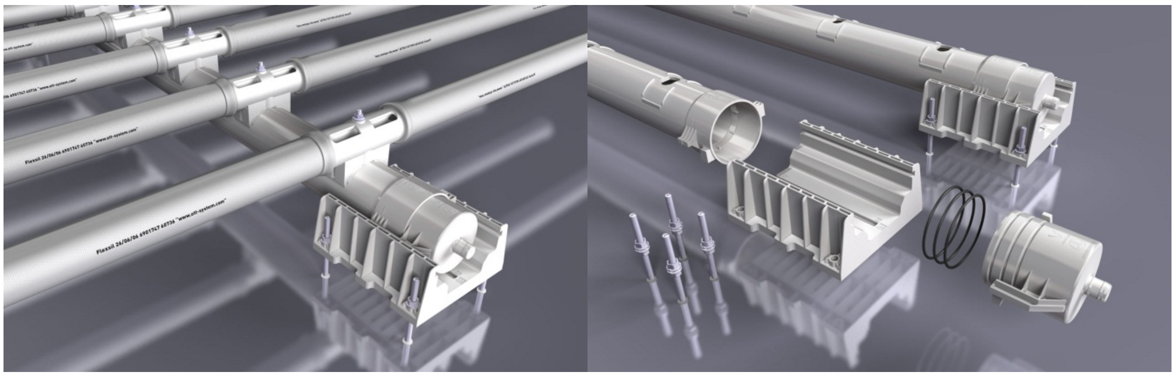


Figure 2
OTT Diffuser & Piping Assembly

Membrane Panels: The efficiency of a given air diffusion device is affected by many factors and one of the most important is the flux rate. In general, spreading the air out over a larger area decreases the flux rate and increases the oxygen transfer efficiency. To take advantage of this fact, various manufacturers produce rather large membrane panels which provide transfer rates that are moderately better than those published for disc or tubular membranes. Sanitaire, Ovivo, and Parkson produce membrane panels that have been used successfully at various WWTPs and these products should be considered under the current analysis. Figure 3 presents various photographs showing the membrane panels that are under consideration.

Sanitare Gold Series

Ovivo Aerostrip

Parkson Hiox

Figure 3
Membrane Panels Offered By Sanitaire, Ovivo, & Parkson

In order to fully evaluate the various diffuser options, the City and Tetra Tech developed a Request for Information (RFI) that was transmitted to various aeration system vendors. The RFI included the following criteria for sizing and development of budgetary costs.

Table 3
Summary of DAR Oxygen Requirements at Design Criteria for Equipment Comparisons

Parameter	Current		Future (Rated Capacity)	
	Flow (MGD)	Oxygen Required (lbs/day)	Flow (MGD)	Oxygen Required (lbs/day
Average Daily Condition	56.0	50,000	96.0	70,000
Maximum Daily Condition	100.8	90,000	172.8	126,000

1. Basic Sizing Methodology: Per WEF MOP-8
2. Alpha: 0.55
3. Beta: 0.95
4. Operating DO @ Average Conditions: 2.0 mg/L
5. Operating DO @ Maximum Day Conditions: 1.0 mg/L
6. Liquid Temperature: 30 Degrees C
7. Minimum Mixing Requirement: 0.12 SCFM/SF
8. Oxygen Demand Distribution
   - Zone 1: 32% of Total
   - Zone 2: 28% of Total
   - Zone 3: 20% of Total
   - Zone 4: 10% of Total
   - Zone 5: 6% of Total
   - Zone 6: 4% of Total

In addition to the above criteria, the manufacturers were advised that the floor cover system for the first three stages of each train should be compatible with submersible mixers sized for an intensity of 25 HP/million gallons.

The manufacturers provided detailed proposals that result in a total of eight feasible options. Each option is summarized below.

Option 1: Aquarius Disc Membranes (Standard Density): A "standard density" configuration featuring 9-inch membrane discs is being offered by Aquarius as one option. This configuration includes 14,576 diffusers and Schedule 40 PVC floor cover piping. The manufacturer recommends a 5'-0" on-center pipe support spacing in the first three process zone to allow the use of submersible mixers in these basins. The remaining zones would have supports at 7'-6" on-center. Attachment A presents the proposal from Aquarius for this option.

Option 2: Aquarius Disc Membranes (High Efficiency): This option is nearly identical to Option 1 with the only real difference being the number of diffusers supplied. This configuration includes 21,768 diffusers, which would increase the efficiency over Option 1 by about 6%. Attachment A presents the proposal from Aquarius for this option as well as Option 1.

Option 3: SSI Disc Membranes: SSI is proposing a 9-inch disc configuration that includes 24,748 diffusers and Schedule 80 PVC floor cover piping. SSI offers several options with regard to membrane material; however, they seem to strongly recommend an EPDM membrane with a Teflon coating for this project. The manufacturer is recommending a 7'-6" on-center pipe support spacing in all process zones and they are suggesting "clear areas" near any mixers to eliminate potential for piping or diffuser failure due to lateral loads. The efficiency provided under this alternative is similar to Option 2. Attachment B presents the proposal from SSI for this option.

Option 4: Sanitaire Disc Membranes: Sanitaire is offering a 9-inch disc configuration that includes 12,452 diffusers with Schedule 80 PVC piping for manifolds and Schedule 40 PVC piping for laterals. The manufacturer is recommending a 7'-6" on-center pipe support spacing in all process zones. They have also indicated that their configuration is compatible with submersible mixers. The efficiency provided under this alternative is similar to Option 1. Attachment C presents the proposal from Sanitaire for this option.

Option 5: Sanitaire Panel & Disc Membrane Combination: In order to provide a high efficiency alternative Sanitaire is suggesting a configuration that includes 3,836 membrane panels and 2,016 disc diffusers. The pipe material, wall thicknesses, and support spacing recommendations are identical to those stated for Option 4. The efficiency provided under this configuration is about 6% better than the efficiency provided under Option 2. Attachment D presents the proposal from Sanitaire for this option.

Option 6: OTT Tubular Membranes: OTT is offering a tubular membrane configuration that includes 3,568 diffusers, Schedule 10 stainless steel manifold piping, and polypropylene laterals. It should be noted that in the past OTT was offering stainless steel laterals but appears that polypropylene is being proposed for economic reasons. The manufacturer recommends a 10'-0" on-center pipe support spacing for the manifolds and a 5'-11" on-center spacing for lateral supports. The manufacturer has stated that their configuration is compatible with mixing equipment; however, it appears that they have some reservations about using submersible mixers. The efficiency provided under this alternative is similar to Option 2. Attachment E presents the proposal from OTT for this option.

Option 7: Ovivo Membrane Panels: Ovivo's proposal suggests 1,600 membrane panel diffusers and Schedule 40 PVC floor cover piping. The manufacturer recommends a 5'-0" on-center pipe support spacing and has stated that the proposed configuration is fully compatible with submersible mixers. The efficiency provided by the Ovivo system is comparable to the efficiency provided by the Sanitaire membrane panels. Attachment F presents the proposal from Ovivo for this option.

Option 8: Parkson Membrane Panels: Parkson is proposing a system that includes 412 membrane panels that measure 4'-0" wide by 12'-0" long. Each panel would be fed by flexible tubing that extends from a stainless steel header that is located above the process liquid, therefore, floor cover piping and related supports would not be provided. The manufacturer has indicated that their proposed configuration would be compatible with submersible mixers with a few restrictions. The efficiency provided under this alternative is similar to Options 1 and 4 even though the Parkson panel is marketed as a "premium efficiency" system. Also, the suggested system seems to have fairly high backpressure values, which increases power costs. Attachment G presents the proposal from Parkson for this option

In order to evaluate the economics of the various system, and to compare the various features of the equipment, capital, operating, and present worth costs have been estimated and summarized in Table 4 along with various other parameters.

Table 4
Summary of Diffused Aeration Equipment Options & Associated Costs

Parameter	Aquarius Technologies Standard Efficiency	Aquarius Technologies High Efficiency	SSI	Sanitaire[3]	Sanitaire[4]	OTT	Ovivo	Parkson
General Diffuser Information								
Type	Membrane Disc Fine Bubble	Membrane Disc Fine Bubble	Membrane Disc Fine Bubble	Membrane Disc Fine Bubble	Membrane Panels & Membrane Discs	Tubular Membranes	Membrane Panels	Membrane Panels
Size	9" Disc	9" Disc	9" Disc	9" Disc	9" Discs & 2 Different Panel Sizes: 4" Wide x 4'-11' Long/4" Wide X 7'-6" Long	4" Diameter Tubes, 9'-10" Long	2 Sizes: 7" Wide x 9'-10' Long' & 7" wide x 11'-6" Long	4'-0" Wide x 12'-0" Long
Membrane Holder	Sonic & Solvent Welded PVC Holder Purported to be Stronger Than Pipe Material	Sonic & Solvent Welded PVC Holder Purported to be Stronger Than Pipe Material	Polypropylene Saddle is Installed On Pipe & Polypropylene Diffuser Holder is Attached to Saddle Via Threaded Connection	Solvent Welded PVC Holder with Integral Check Valve	Disc: Solvent Welded PVC Holder with Integral Check Valve, Panel: PVC Diffuser Body	Molded Polypropylene Support Tube	PVC Frame w/ Membrane Retaining Clips	Stainless Steel Frame w/ Membrane Retaining Clips
Membrane	EPDM	EPDM	EPDM with Teflon	EPDM	Disc: EPDM, Panel: Polyurethane	Silicone	Polyurethane	Polyurethane
Total No. of Diffusers Recommended	14,576	21,768	24,748	12,452	5,464	3,568	1,600	412 panels
Stated Efficiencies								
@ AADF = 56.0 MGD	34.55%	36.86%	35.85%	32.9%	37.2%	34.30%	38.18%	34.00%
@MDF = 100.8 MGD	32.74%	35.00%	36.10%	31.5%	35.4%	30.73%	35.48%	Not Provided
@ AADF = 96.0 MGD	33.16%	35.43%	34.00%	31.9%	35.9%	31.76%	36.11%	30.50%
@ MADF = 172.8 MGD	31.42%	33.65%	35.12%	30.3%	33.6%	28.07%	33.70%	Not Provided
Stated Air Flow Requirements (SCFM)								
@ AADF = 56.0 MGD	14,104	13,219	13,455	14,192	12,387	13,024	13,324	14,275
@MDF = 100.8 MGD	23,138	21,642	20,772	23,375	20,758	23,876	21,625	24,191
@ AADF = 96.0 MGD	20,572	19,251	19,864	20,702	18,298	19,920	19,119	20,846
@ AADF = 172.8 MGD	33,753	31,519	29,897	34,098	30,798	36,584	31,529	33,871
Pressure @ Top of Drop Leg	7.5 -7.8 psig	7.4 - 7.6 psig	7.5 psig	7.6 - 8.2 psig	7.6 -7.9 psig	7.7 - 8.1 psig	8.5 - 8.8 psig	8.3 - 8.7 psig
Floor Cover Piping								
Material	PVC	PVC	PVC	PVC	PVC	Manifolds: 304L Stainless Steel Laterals: 4" Polypropylene	PVC	N/A: Panels Are Fed by Hoses
Schedule/SDR/Wall thickness	Schedule 40	Schedule 40	Schedule 80	Manifolds: Schedule 80 Laterals: Schedule 40	Manifolds: Schedule 80 Laterals: Schedule 40	Manifolds: Schedule 10 Laterals: 8 mm Wall Thickness	Schedule 40	N/A: Panels Are Fed by Hoses
Support Spacing	5'-0" OC in Zones w/ Mixers, 7'-6" OC in Zones w/o Mixers	5'-0" OC in Zones w/ Mixers, 7'-6" OC in Zones w/o Mixers	7'-6" OC	7'-6" OC	7'-6" OC	Manifolds: 10'-0" OC (Max) Laterals: 5'-11" OC	5'-0" OC	N/A: Panels Are Fed by Hoses
Compatible with Mixers	Yes	Yes	Yes (Conditionally)	Yes	Yes	Under Certain Circumstances	Yes	Yes (Conditionally)
Capital Costs								
Equipment	$480,000	$590,000	$898,000	$469,000	$900,000	$601,000	$1,050,000	$970,000
Sales Tax	$34,000	$41,000	$63,000	$33,000	$63,000	$42,000	$74,000	$68,000
Installation	$160,000	$160,000	$160,000	$160,000	$130,000	$130,000	$60,000	$60,000
Sub-Total	$674,000	$791,000	$1,121,000	$662,000	$1,093,000	$773,000	$1,184,000	$1,098,000
Overhead & Profit	$101,000	$119,000	$168,000	$99,000	$164,000	$116,000	$178,000	$165,000
Total Capital Cost	$775,000	$910,000	$1,289,000	$761,000	$1,257,000	$889,000	$1,362,000	$1,263,000

AADF Air Flow Req., HP, & Power Cost	Aquarius Std. Qa (SCFM)	HP	Annual Power Cost	Aquarius High Eff. Qa (SCFM)	HP	Annual Power Cost	SSI Qa (SCFM)	HP	Annual Power Cost	Sanitaire[3] Qa (SCFM)	HP	Annual Power Cost	Sanitaire[4] Qa (SCFM)	HP	Annual Power Cost	OTT Qa (SCFM)	HP	Annual Power Cost	Ovivo Qa (SCFM)	HP	Annual Power Cost	Parkson Qa (SCFM)	HP	Annual Power Cost
@ AADF = 56.0 MGD (2013)	14,104	566	$311,000	13,219	535	$294,000	13,455	543	$299,000	14,192	568	$312,000	12,387	507	$279,000	13,024	528	$290,000	12,192	526	$289,000	14,275	746	$411,000
@ AADF = 56.9 MGD (2014)	14,331	574	$316,000	13,431	542	$298,000	13,671	551	$303,000	14,420	576	$317,000	12,586	514	$283,000	13,233	535	$295,000	12,388	532	$293,000	14,504	754	$415,000
@ AADF = 57.8 MGD (2015)	14,557	582	$320,000	13,644	550	$303,000	13,887	558	$307,000	14,648	674	$371,000	12,785	521	$286,000	13,443	543	$299,000	12,584	539	$297,000	14,734	761	$419,000
@ AADF = 58.7 MGD (2016)	14,784	590	$325,000	13,856	557	$307,000	14,104	566	$311,000	14,876	682	$375,000	12,984	527	$290,000	13,652	550	$303,000	12,780	545	$300,000	14,963	769	$423,000
@ AADF = 59.6 MGD (2017)	15,011	665	$366,000	14,069	565	$311,000	14,320	574	$316,000	15,104	690	$379,000	13,183	534	$294,000	13,861	557	$307,000	12,976	552	$304,000	15,193	777	$427,000
@ AADF = 60.5 MGD (2018)	15,237	673	$370,000	14,281	572	$315,000	14,536	581	$320,000	15,332	697	$384,000	13,382	541	$298,000	14,071	565	$311,000	13,172	558	$307,000	15,422	784	$432,000
@ AADF = 61.4 MGD (2019)	15,464	681	$375,000	14,494	580	$319,000	14,752	589	$324,000	15,561	705	$388,000	13,581	547	$301,000	14,280	572	$315,000	13,368	565	$311,000	15,652	792	$436,000
@ AADF = 62.3 MGD (2020)	15,691	689	$379,000	14,706	587	$323,000	14,969	663	$365,000	15,789	712	$392,000	13,781	554	$305,000	14,489	580	$319,000	13,564	571	$314,000	15,881	800	$440,000
@ AADF = 63.2 MGD (2021)	15,917	697	$384,000	14,919	662	$364,000	15,185	671	$369,000	16,017	720	$396,000	13,980	561	$309,000	14,699	654	$360,000	13,760	578	$318,000	16,110	807	$444,000
@ AADF = 64.1 MGD (2022)	16,144	705	$388,000	15,131	669	$368,000	15,401	679	$373,000	16,245	728	$401,000	14,179	567	$312,000	14,908	661	$364,000	13,955	584	$322,000	16,340	815	$448,000
@ AADF = 65.0 MGD (2023)	16,371	713	$392,000	15,343	677	$372,000	15,617	686	$378,000	16,473	735	$405,000	14,378	574	$316,000	15,117	669	$368,000	14,151	712	$392,000	16,569	822	$453,000
@ AADF = 65.9 MGD (2024)	16,597	721	$397,000	15,556	684	$376,000	15,834	694	$382,000	16,701	743	$409,000	14,577	581	$320,000	15,326	676	$372,000	14,347	719	$395,000	16,799	830	$457,000
@ AADF = 66.8 MGD (2025)	16,824	729	$401,000	15,768	692	$381,000	16,050	702	$386,000	16,929	751	$413,000	14,776	678	$373,000	15,536	683	$376,000	14,543	725	$399,000	17,028	838	$461,000
@ AADF = 67.7 MGD (2026)	17,051	737	$406,000	15,981	699	$385,000	16,266	709	$390,000	17,157	758	$417,000	14,975	685	$377,000	15,745	691	$380,000	14,739	732	$403,000	17,257	845	$465,000
@ AADF = 68.6 MGD (2027)	17,277	745	$410,000	16,193	707	$389,000	16,482	717	$395,000	17,385	766	$422,000	15,174	692	$381,000	15,954	698	$384,000	14,935	738	$406,000	17,487	853	$469,000
@ AADF = 69.5 MGD (2028)	17,504	753	$414,000	16,406	714	$393,000	16,699	725	$399,000	17,613	774	$426,000	15,373	699	$384,000	16,164	706	$388,000	15,131	745	$410,000	17,716	861	$474,000
@ AADF = 70.4 MGD (2027)	17,731	761	$419,000	16,618	722	$397,000	16,915	732	$403,000	17,841	781	$430,000	15,572	705	$388,000	16,373	713	$392,000	15,327	751	$413,000	17,946	868	$478,000
@ AADF = 71.3 MGD (2030)	17,957	769	$423,000	16,831	729	$401,000	17,131	740	$407,000	18,069	789	$434,000	15,771	712	$392,000	16,582	720	$396,000	15,523	758	$417,000	18,175	876	$482,000
@ AADF = 72.2 MGD (2031)	18,184	777	$428,000	17,043	737	$405,000	17,347	748	$411,000	18,298	797	$438,000	15,970	719	$395,000	16,792	728	$401,000	15,719	764	$420,000	18,405	884	$486,000
@ AADF = 73.1 MGD (2032)	18,411	785	$432,000	17,256	744	$410,000	17,564	755	$416,000	18,526	804	$443,000	16,169	725	$399,000	17,001	735	$405,000	15,915	771	$424,000	18,634	891	$490,000
Present Worth of Power Cost	$4,252,000			$3,929,000			$4,011,000			$4,434,000			$3,477,000			$3,881,000			$3,905,000			$5,076,000		

Parameter	Aquarius Technologies Standard Efficiency	Aquarius Technologies High Efficiency	SSI	Sanitaire[3]	Sanitaire[4]	OTT	Ovivo	Parkson
Diffuser Maintenance/Replacement								
Suggested Maintenance	Weekly Air Bumping & Moisture Purging, Clean & Inspect Diffusers Every 3 Years	Weekly Air Bumping & Moisture Purging, Clean & Inspect Diffusers Every 3 Years	Bi-Weekly to Monthly Air Bumping & Moisture Purging, Clean & Inspect Diffusers Annually	Weekly Air Bumping & Moisture Purging, Clean & Inspect Diffusers Annually	Weekly Air Bumping & Moisture Purging, Clean & Inspect Diffusers Annually	Daily Over-Inflation, Periodic Pressure Washing & Flushing with Formic Acid (Unspecified Frequency)	Daily Relaxing Cycle/Organic Acid Feed Every 1 -2 Years	Weekly Membrane Flexing
Membrane Replacement Frequency	Every 10 Years Per Manufacturer, Membranes Cost $3.00 Each, Assume Replacement @ Year 10 & Year 20 ($44,000 Each Replacement)	Every 10 Years Per Manufacturer, Membranes Cost $3.00 Each, Assume Replacement @ Year 10 & Year 20 ($65,000 Each Replacement)	Every 20 Years Per Manufacturer, Membranes Cost $4.25 Each, Assume Replacement @ Year 20 ($105,000 Replacement Cost)	Every 10 Years Per Manufacturer, Membranes Cost $4.25 Each, Assume Replacement @ Year 10 & Year 20 ($53,000 Each Replacement)	Every 10 Years Per Manufacturer, Disc Membranes Cost $4.25 Each, Panel Membranes Cost $39.25 EachAssume Replacement @ Year 10 & Year 20 ($159,000 Each Replacement)	Manufacturer States That Membrane Life Will Exceed 10 Years, Assume Replacement @ Year 15 ($182,000)	Every 10 - 15 Years Per Manufacturer, Assume Replacement @ Year 10 & Year 20 ($300,000 Each Replacement)	Every 10 Years Per Manufacturer, Membranes Cost $1,000.00 Each, Assume Replacement @ Year 10 & Year 20 ($412,000 Each Replacement)
Present Worth of Membrane Replacement	$38,000	$57,000	$33,000	$46,000	$138,000	$76,000	$261,000	$359,000
Total 20-Year Present Worth	**$5,065,000**	**$4,896,000**	**$5,333,000**	**$5,241,000**	**$4,872,000**	**$4,846,000**	**$5,528,000**	**$6,698,000**

Notes:
1. Power cost are based on performance curves for the existing blowers and a unit cost for energy of $0.08/kWh.
2. Present worth values are based on an interest rate of 6.0%.

As shown in Table 4, the membrane disc and tube options, and the Sanitaire panel option, have present worth costs that are fairly close to one another. To provide further insight into the desirability of the various options, references have been contacted for each option. The responses obtained from the references are summarized in Table 5.

As shown in Table 5, almost all references provided positive feedback regarding the products. One notable exception involved the Parkson HiOx panels. In two cases the references stated that they would not purchase Parkson's membrane panels again due to premature membrane failures. It should be noted that positive references can be expected when the manufacturers provide the reference contacts as they generally try to ensure that their products are viewed in a positive light in order to secure future business.

Preliminary Conclusion & Recommendations

First, it should be restated that final oxygen requirements have not been fully established and that this initial analysis is simply a comparison of equipment alternatives based on the current mode of operation. Despite the various uncertainties that currently exist in this project, the conclusions that can be drawn from the analyses presented will remain valid even if oxygen demands vary due to decommissioning the HPO facilities and/or increasing "spike line" flows to enhance nitrogen removal. Accordingly, the following initial conclusions and recommendations are offered.

1. The membrane panels offered by Ovivo and Parkson appear to have high capital and present worth costs.

2. The various membrane disc options have comparable present worth costs and they can probably considered equal in economic terms. It is recognized that the Aquarius high efficiency option is shown to be more economical than the SSI and Sanitaire disc options, but it must be noted that SSI and Sanitaire can adjust their diffuser densities and flux rates to achieve comparable efficiencies.

3. The Sanitaire membrane panel/disc option and OTT tubular membranes are competitive on a present worth cost basis. The Gold Series diffuser offered by Sanitaire has been installed at only four (4) WWTPs within the United States; therefore, this particular product will need to be carefully evaluated.

4. Plant visits should be scheduled to observe the Aquarius and Sanitaire discs, and the OTT tubular diffusers. Suggested WWTPs include:
   - Dade City and/or Collier County WWTPs (Aquarius)
   - Polk County Northwest WWTP (OTT)
   - St. Petersburg SWWRF (Sanitaire)

   Note: SSI does not have any Florida installations that include 9-inch membrane discs. Also, Sanitaire does not have any Florida installations that include the Gold Series membrane panels.

END OF MEMORANDUM

JPT/slh/sma/08494-12002/del1/DA System Alternatives

Table 5
Summary of Reference Feedback Regarding Various Types of Diffusers

Manufacturer	Contact Person, Plant Name, & Location	Plant Capacity & Current Flow	Treatment Upstream of Diffusers				Equipment Type	Installation Date	Treatment Process	No. of Diffusers	Floor Cover Piping	Aeration Operation	Performance / Maintenance								Recommend Product	Comments
			Screens	Grit Removal	Primary Clarifiers	Other							Membrane Replacement	Complete Diffuser Replacement	Adequate O2 Transfer/DO	Adequate Mixing	Floor Cover Piping Failure	Membrane Failure	Fouling	Increase in Blower Backpressure		
Aquarius	William Balzer, Nansemond WWTP, Suffolk, VA	30.0 MGD/17.0 MGD	Yes	Yes	Yes	N/A	9" Membrane Disc	2009- 2010	5-Stage BNR	17,500	PVC	Continuous	No	Yes	Yes	Yes	No	No	No	No	Yes	Will soon be transitioning to ammonia/DO control strategy, which will cycle the air on and off. Excellent performance for approx. 13 years.
Aquarius	Troy Stephens, Atlantic Beach WWTP, Atlantic Beach, FL	3.5 MGD/1.8 MGD	Yes	No	No	N/A	9" Membrane Disc	March 2012	Bardenpho	Approx. 1,000	PVC	Continuous	No	No	Yes	Yes	Yes	No	No	No	Yes	None
Aquarius	Dennis Schump, Greeley WPCF, Greeley, CO	14.7 MGD/7.4 MGD	Yes	Yes	Yes	N/A	9" Membrane Disc & Ceramic	2010	Conventional	4,000 per basin, 4 Basins	PVC	Continuous	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Half of 1 basin has the Aquarius membrane diffusers. The remaining diffusers are from other manufacturer.
Aquarius	Frank Russo, Meriden WWTP, Meriden, CT	11.6 MGD/10.0 MGD	Yes	Yes	Yes	N/A	9" Membrane Disc	2007 - 2009	BNR	Over 5,000	PVC	Continuous	No	No	Yes	Yes	No	No	No	No	Yes	System has worked flawlessly since installed.
Aquarius	Vlad Petran, GE Both WWTP, Mississauga, ON	137.0 MGD/111.0 MGD	Yes	Yes	Yes	Chem. Add.	9" Membrane Disc	2009 - 2010	Conventional	6 Tanks (25.0 m x 82.5 m each)	PVC	Continuous	No	No	Yes	Yes	No	No	No	No	Yes	System performs as intended, no complaints.
SSI	Jason Pittsinger Panther Creek WWTP Frisco, TX	10.0 MGD/4.2 MGD	Yes	Yes	Yes	N/A	9" Membrane Disc	2010	Extended Aeration	3,360	PVC	Continuous	No	No	Yes	Yes	No	No	No	No	Yes	None
Sanitaire - Membrane Disc	Kevin McKinnon, Eagle River WWTP, Eagle River, AK	2.5 MGD/1.4 MGD	Yes	Yes	Yes	N/A	9" Membrane Disc	1991	Conventional	2,400	PVC	Continuous	Yes	No	Yes	Yes	No	No	No	No	Yes	Higher air flows needed for mixing, DO = 7 mg/L. Diffuser membranes last about 8 years. Mechanical mixers are desired. Working to try ON/OFF aeration for denitrification to minimize soda ash usage.
Sanitaire - Membrane Disc	Hector Ortiz, Goodyear WWTP, Goodyear, AZ	4.0 MGD/3.3 MGD	Yes	Yes	No	N/A	9" Membrane Disc	2007- 2008	BNR	4,110	Stainless Steel/PVC	Continuous	No	No	Yes	Yes	No	No	Yes	Unk.	Yes	Overall the system has been trouble free and performs well. Suggest Installing dividing walls between each aeration zone with a top to bottom S-curve flow pattern designed to define each aeration zone and minimize DO carryover.
Sanitaire - Membrane Disc	Robert Lucero, La Junta WWTP, La Junta, CO	2.3 MGD/1.1 MGD	Yes	Yes	Yes	N/A	9" Membrane Disc	Basin #1: 1996, Basin#2: 1991, Basin #3: 1987	Conventional	Basin #1 & #3: 3,554 7" Membranes, Basin #2: 845 9" Membranes	PVC	Continuous	Yes	Yes	Yes	Yes	No	Yes	Min.	No	Yes	None
Sanitaire - Membrane Disc	Doug Lipsomb, Prairie Creek WWTP, Lewisville, TX	12.0 MGD/7.8 MGD	Yes	Yes	No	N/A	9" Membrane Disc	1995, 1997, 2004 and 2006 (Different Basins)	Conventional	Approx. 11,000 (Aeration Basin & Digesters)	PVC	Continuous	No	Yes	Yes	Yes	No	No	No	No	Yes	Changed the original ceramic diffusers to the membrane type in several basins. The membrane type are very good diffusers.
Sanitaire - Membrane Disc	Brian Quick, SpringbrookWWTP, Naperville, IL	13.0 MGD/2.0 MGD	Yes	Yes	No	N/A	9" Membrane Disc	Jun-05	Conventional	1584	PVC	Continuous	No	No	Yes	Yes	No	No	No	No	Yes	On rare occasions the diffusers have rotated from the upright position due to a loose coupling. Has only happened a couple of times since 1999. As long as the couplings are tight there are no problems.
Sanitaire - Gold Series	Steve Simons, Village of Cleveland WWTP, Cleveland, WI	0.24 MGD/0.16 MGD	Yes	No	No	No	Membrane Panel	December 2010	Conventional	75	PVC	Continuous	No	No	Yes	Yes	Yes	No	No	No	Yes	One pipe coupling failed in October 2011. Xylem replaced faulty coupling. Some additional solids build up under diffuser grid. Old supports from Xylem's "Silver/Series" were used on the Gold Series product. Recommendations: Lowering units closer to the floor will reduce solids build up.
Sanitaire - Gold Series	Alan Grooms, Nine Springs WWTP, Madison, WI	56.0 MGD / 38.0 MGD	Yes	Yes	Yes	No	Membrane Panel	August 2012	Conventional	396	PVC	Continuous	No	No	Yes	Yes	No	No	No	No	Yes	Full floor system looks tough to get into for maintenance. Membrane replacement will be tough. In the right situation this system looks like it may make sense from an O2 transfer, cost efectiveness, etc. standpoint.
Sanitaire - Gold Series	Curt Zuvela, Edmonds WWTP, Edmonds, WA	11.8 MGD/5.8 MGD	Yes	No	Yes	N/A	Membrane Panel	January 2013	Conventional	No Response / Unknown	PVC	Continuous	No	No	Yes	Yes	No	No	No	No	Yes	None

Table 5
Summary of Reference Feedback Regarding Various Types of Diffusers

Manufacturer	Contact Person, Plant Name, & Location	Plant Capacity & Current Flow	Treatment Upstream of Diffusers				Equipment Type	Installation Date	Treatment Process	No. of Diffusers	Floor Cover Piping	Aeration Operation	Performance / Maintenance								Recommend Product	Comments
			Screens	Grit Removal	Primary Clarifiers	Other							Membrane Replacement	Complete Diffuser Replacement	Adequate O2 Transfer/DO	Adequate Mixing	Floor Cover Piping Failure	Membrane Failure	Fouling	Increase in Blower Backpressure		
OTT	Shannon Grant, Food Process WWTP, Lis Aliments Vari, Canada	0.03 MGD	Yes	No	No	N/A	FLEXSIL Tubular Membranes	2005	Membrane Bioreactor	No Response / Unknown	No Response / Unknown	Continuous	No	No	Yes	Yes	No	No	No	No	Yes	It is the best membrane system they have used in their projects.
OTT	Tim Snider, Troy WWTP, Troy, OH	7.0 MGD / 5.0 MGD	Yes	Yes	Yes	N/A	FLEXSIL Tubular Membranes	2001	Contact Stabilization	900	Stainless Steel	Continuous	No	No	Yes	Yes	No	No	No	No	Yes	None
OTT	Tracy McPheron, Van Wert WWTP, Van Wert, Ohio	4.0 MGD/2.8 MGD	Yes	Yes	Yes	N/A	FLEXSIL Tubular Membranes	2000	Conventional	1,072	Stainless Steel	Continuous	No	Yes	Yes	Yes	No	No	No	No	Yes	None
OTT	Joe Hanks, Dale Service WWTP, Dale City, Va	4.6 MGD/3.0 MGD	Yes	Yes	No	N/A	FLEXSIL Tubular Membranes	2002	SBRs	2,800	No Response / Unknown	On/Off	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Membranes replaced @ 7 years
OTT	Joseph Baxter, Dry Creek WWTP, Villa Hills, KY	46.5 MGD/30.0 MGD	Yes	Yes	Yes	N/A	FLEXSIL Tubular Membranes	2000	Conventional	8,600	Manifolds: Stainless Steel, Laterals: PVC	Continuous	No	A few per year	Yes	Yes	No	No	Yes	No	Yes	Fouling resulted from blower being off-line for extended periods of time. Blower backpressure still operating around 11.5 - 12.0 psi.
OTT	Felton Carnell, Jackson Pike WWTP, Columbus, OH	100.0 MGD/80.0 MGD	Yes	Yes	Yes	N/A	FLEXSIL Tubular Membranes	2009/2010	Step Feed	1,488 Coarse Bubble & 16,248 FLEXSIL	Stainless Steel	Continuous	No	No	Yes	Yes	No	No	No	No	Yes	Product is well made. Recommendations: If possible, have the vendor involved from the beginning with the design professional, and look at not only the diffusers, but the entire system to make sure that blowers, piping and controls all work in concert with the diffusers. (Comment from Gary Hickman - Plant Manager)
Ovivo	Bob Farrell, Port of Sunnyside Industrial WWTP, Sunnyside, WA	0.55 MGD / 0.55 MGD	No	No	No	No	Membrane Panel	2005	Sequencing Batch Reactor	468	HDPE	On/Off	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Periodic replacement of single membranes (take basins down annually). Occasional tearing of single membranes. Fouling: Carbonates - Injection of acetic acid clears membranes pores. Increase in Blower Backpressure: Acid injection remedies problem.
Ovivo	Robert Leber Abington, PA	3.91 MGD / 3.3 MGD	Yes	Yes	Yes	Anoxic Zone	Membrane Panel	2008	A^2O	428	PVC	Continuous	No	Yes	Yes	No	Yes	No	No	No	Yes	Complete diffuser replacement in one diffuser. Floor Cover Piping: Three compression fittings failed at diffuser connection. Suggested Modifications: Add a mechanical mixer in the fourth aeration zone where oxygen demand is low.
Ovivo	Jeff Noelte Regional Water Recycling Plant No. 4 Rancho Cucamonga, CA	14.0 MGD / 10.0 MGD	Yes	Yes	Yes	N/A	Membrane Panel	Phase 1: 2005 Phase 2: June 2009	BNR; Similar to MLE Process	Phase 1: 618 Phase 2: 2,160	HDPE	Continuous	No	No	Yes	Yes	No	Yes	Yes	No	Yes	Ovivo system provides adequeate O2 transfer - 1 ppm set point in first oxic zone and 2 ppm set point in second oxic zone. Adequate Mixing: 3 mixers (4 HP Motor) and 1 mixed liquor return pump (40 HP motor) per train. Membrane Failure: 22 drop legs isolated due to failed membranes.
Ovivo	Larry Willman, Bremerton WWTP, Bremerton, WA	Summer 11.0 MGD/ Winter 15.5 MGD	Yes	Yes	Yes	No	Membrane Panel	2005	High Rate Activated Sludge	290	HDPE	Continuous	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Membrane Replacement Frequency: 8 - 9 yrs, after that time several membranes have failed due to tears. O2 Transfer: 80% of original O2 transfer after 10 yrs. Fouling: Quarterly cleaning prevents it. Increase in Blower Backpressure: Gradual increase over 3-4 month period (flexing helps a lot)

Table 5
Summary of Reference Feedback Regarding Various Types of Diffusers

Manufacturer	Contact Person, Plant Name, & Location	Plant Capacity & Current Flow	Treatment Upstream of Diffusers				Equipment Type	Installation Date	Treatment Process	No. of Diffusers	Floor Cover Piping	Aeration Operation	Performance / Maintenance								Recommend Product	Comments
			Screens	Grit Removal	Primary Clarifiers	Other							Membrane Replacement	Complete Diffuser Replacement	Adequate O2 Transfer/DO	Adequate Mixing	Floor Cover Piping Failure	Membrane Failure	Fouling	Increase in Blower Backpressure		
Parkson	Doug Haussel, Bergen Point WWTP, West Babylon, NY	30 MGD/ 24 MGD	Yes	Yes	Yes	N/A	HiOx Aeration Panel	1992-1996	Conventional	120	N/A	Continuous	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	Labor intensive-membranes must be "flexed" each week to release biofilm & caustic washed annually (minimum). Frequent membrane ruptures/high cost of membranes. Energy savings are significant , but maintenance requirements make this system undesirable.
Parkson	Joseph McIlvenny, New CastleWWTP, New Castle, PA	17.5 MGD/9.0 MGD	Yes	Yes	Yes	N/A	HiOx Aeration Panel	1999	Conventional	216	PVC	Continuous	No	No	Yes	Yes, No	No	Yes	Yes	No	No	Operators did not like weekly membrane flexing. Excessive maintenance required on re-anchoring panels to floor. When panels come loose, they swing around and damage neighboring panels. New Castle Sanitation Authority awarded a bid to Aquarius for a complete system replacement.
Parkson	Scott Hamby, Scotts Valley WWTP, Scotts Valley, CA	1.5 MGD/0.9 MGD	Yes	Yes	No	FEQ	HiOx Aeration Panel	1997	Conventional	40	PVC laterals	Continuous	Yes	No	Yes	Yes	No	Yes	No	No		Old style panel (Scotts Valley model) has chronic maintenance issues. The bolts in the frame that secure the membrane fail (sheer in two) causing air leaks and need for removing system from service repairs. The system has been modified.
Parkson	Kathy Perez, South Kingstown WWTF, Narragansett, RI	5.0 MGD/2.5 MGD	Yes	Yes	No	N/A	HiOx Aeration Panel	1990	Conventional	No Response / Unknown	PVC laterals	Continuous	Yes	No	Yes	Yes	No	Yes	Yes	Unk	Yes	None
Parkson	Vance Summerhill, Westminster WWTP, Westminster, MD	5.0 MGD/4.80 MGD	Yes	Yes	No	N/A	HiOx Aeration Panel	2000	Conventional	84	PVC	Continuous	No	No	Yes	Yes	No	No	No	No	Yes	The operators "flex" the membranes weekly as per the manufacturers instructions and we have had excellent performance for approx. 13 years.
Parkson	Paul Burris, Woodridge WWTP, Dupage County, IL	12.0 MGD/8.0 MGD	Yes	Yes	No	N/A	HiOx Aeration Panel	2012	Conventional	375	PVC	Continuous	No	Yes	Yes	Yes	No	Yes	No	No	Yes	None

TETRA TECH, INC.

ATTACHMENT A
AQUARIUS MEMBRANE DISC PROPOSAL
(OPTIONS 1 & 2)

AQUARIUS
TECHNOLOGIES INC.

January 14, 2013

Mr. John Toomey
Tetra Tech

Re: Tampa DAR Project
Proposal No. 4115-13

Mr. Toomey:

Aquarius is pleased to submit the enclosed conceptual design proposal for the supply of a Fine Pore Aeration System for the Tampa DAR Project. This proposal is submitted in response to the RFP dated January 8, 2013. In addition to the specific evaluation data requested, we have also included supporting documentation for your consideration.

Contained herein our proposal table of contents provides a detailed directory to the specific items contained in the proposal. Section I contains a discussion of Aquarius' experience and system features. Section II contains the requested evaluation criteria. Section III contains the budgetary proposal. Section IV contains brochures and project list.

If you have any questions regarding this proposal, please contact this office or our local agent John Verscharen of TSC Jacobs.

Very truly yours,

David Lauer, P.E.
Vice President – Sales & Marketing

cc: Aquarius Representative:
TSC Jacobs
24156 SR54, Suite 3
Lutz, FL 33549
Ph: (813) 242-2660

AQUARIUS
TECHNOLOGIES INC.

CONCEPTUAL DESIGN PROPOSAL

FOR THE

TAMPA DAR PROJECT

FOR AN

AERATION SYSTEM REPLACEMENT

ENGINEER:
TETRA TECH

REPRESENTATIVE:
TSC JACOBS
24156 SR54, SUITE 3
LUTZ, FL 33549
PH: (813) 242-2660

AQUARIUS PROPOSAL #4115-13

JANUARY 14, 2013

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AQUARIUS
TECHNOLOGIES INC.

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AQUARIUS
TECHNOLOGIES INC.

1

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INTRODUCTION

Aquarius is pleased to have the opportunity of presenting this proposal for the supply of a Fixed Floor Fine Bubble Aeration System for installation at the Tampa DAR Project. This proposal document is submitted in response to the RFP dated January 8, 2013.

Aquarius Technologies Inc. is a privately held company established to provide wastewater treatment solutions for industrial and municipal applications. Headquartered in Port Washington, a northern suburb of Milwaukee, Wisconsin, Aquarius consists of a group of dedicated engineers, scientists and other professionals focused on providing cost-effective solutions to wastewater treatment problems.

Product History

The Aquarius fine pore aeration system has been developed by our team of engineers with over 250 years of combined experience in the design, application, production and operation of wastewater treatment aeration systems. This experience comes with the knowledge that a high performance diffuser requires an equally well engineered piping system to support it. Moreover, our unique experience allowed us to improve upon a basic aeration system design that was well proven over the past 20 years. The Aquarius aeration system is a culmination of this experience.

Aquarius System Advantages - Fine Bubble Diffused Aeration System

Diffuser Holder

The Aquarius diffuser offers several advantages over alternate diffusion devices. The diffuser is mounted in a holder that is sonic and solvent welded in the factory to the crown of the air distribution header. This sonic and solvent welded bond is actually stronger than the pipe material itself, which results in unparalleled long-term structural integrity. The sonic welded bond fuses the holder to the pipe and is the primary connection, whereas the solvent welded bond glues the holder to the pipe and is the secondary connection. With some competitive designs, a metallic rivet is used to fix the diffuser holder to the pipe. The long-term mechanical reliability of this design is suspect, since the plastic will yield with force over time, resulting in leakage or failure at the metal/plastic connection. Moreover, this metallic rivet may not be corrosion resistant to acid cleaning of the diffusers, resulting in mechanical failure. Other competitive designs utilize a small diameter nipple connection and friction fit connection to the header piping. Once again the long-term mechanical reliability of this design is suspect, since plastic will yield with force over time, and the small diameter connection may be insufficient to resist the forces of normal operation and maintenance thereby also resulting in mechanical failure. Finally there are other competitive designs which utilize a clamping saddle to fix the diffuser holder to the pipe. Though this saddle is mechanical sound, it requires the contractor to perform the installation, resulting in the potential for field installation error and higher installed costs than factory installed holder designs.

Membrane Diffuser

The Aquarius membrane is a proprietary EPDM based compound that has 10% less extractable oil than similar type diffusers. This will result in a more chemically stable diffuser thereby providing longer life. The life and performance of a membrane diffuser is dependent on the environment in which it is operating. Some wastewaters are more aggressive to membrane diffusers than others. Our experience has provided us the opportunity of analyzing environments that are especially aggressive toward membrane materials. By focusing on these environments, we are able to understand and analyze how the membrane diffuser element ages with time in service and how this affects diffuser life. By concentrating on these points, we were able to develop the advanced EPDM recipe that is our membrane diffuser. The Aquarius membrane will provide a longer duty of service and at a higher level of efficiency. The cost associated with replacing units sooner and incurring additional power charges should be considered when purchasing equipment. While it is impossible to predict how a specific wastewater will affect the Aquarius membrane diffuser, we can state with confidence that the diffuser life will be longer than other disk diffusers.

In addition to the chemical formulation of the membrane, the production of the diffuser and quality control procedures utilized in the manufacturing process are an extremely important aspect in determining the performance characteristics of the diffuser. Focusing on producing a diffuser with very tight physical dimensions, Aquarius was able to develop a finished product that has 19% improved uniformity of air distribution than other diffusers in the marketplace. This in conjunction with the perforation configuration, results in a diffuser that has a 5% oxygen transfer enhancement over similar diffuser designs. Therefore, the same number of Aquarius diffusers provided will result in higher quantities of oxygen transferred than similar 9" diffuser designs.

Piping Grid

One of the significant differences between the Aquarius system and other manufacturers is our approach to the design of the piping grid. Since a diffused aeration system is only as good as the delivery method of the supplied air, we recommend that considerable time be spent evaluating the pipe jointing and pipe supporting system. As noted above, the Aquarius design approach has been extensively field-tested with proven effectiveness. Everything within the grid system from the 2% titanium dioxide used in the PVC to prevent ultraviolet degradation, to the joint and support system is an integral part of the design. No component is assumed to be trivial or considered simply good enough. As such, we have employed sound engineering concepts in the design and implementation of every piece of equipment. The type of pipe joining is an example of this attention to detail. The Aquarius fixed joint system is not only easier to install but helps prevent the "blow apart" problem found in other systems. For reference, "blow apart" is a condition where the mechanical integrity of the piping system is lost and the pipes actually become separated from the support system during operation. A typical cause of this condition would be a system filling with water when air is lost to the aeration grid and then suddenly reintroduced. This is likely to occur during a loss of power to the blower or other unexpected shutdowns common to most treatment facilities. When the air is resupplied to the grid, a significant water hammer is often created which causes considerable stress on the pipe joints. Any design that does not take these additional forces into account is prone to failure. The two most common forms of fixed joint connections are flanged assemblies or threaded couplings. To reduce the cost to the owner, Aquarius has made an investment in special tooling and designed a unique threaded coupling for use in lieu of the more expensive to install flange system. The Aquarius joint has a greater thread profile and thicker retainer ring resulting in a stronger more reliable joint than similar designs. The sealing o-ring is also compressed on four sides versus two sides producing a greater sealing force. The joint incorporates an anti-rotational feature with infinite angular rotation and reduced joint stress. Other suppliers design their piping joining system with expansion couplings or slip joints. In this configuration, which typically has a maximum pipe engagement of no more than two inches, the ends of the connecting pipes are free to move within the joint. Considerable evidence is available to substantiate that this design significantly increases the chances of leaking and blow apart. The installing contractor must be cautious when installing this type of system. To prevent failure, proper alignment is crucial. Also, the pipe and joints must be installed tight enough to prevent leaking at the joints, yet loose enough to allow for expansion and contraction of the pipe. Under jobsite condition, where installation procedures are often compromised, this is difficult at best.

The mechanical integrity of a fine bubble system is extremely important to long term successful performance. Our system of guide type supports and threaded union joints is field proven in dealing with blower outages and variations in air temperature. These are two areas that have resulted in common mechanical failure of other piping designs. The Aquarius piping design eliminates the potential for blow apart or failure of expansion or slip on type joint fittings commonly occurring with other manufacturers systems.

Made In The USA

When we introduced our diffused aeration system it was done with the intent of providing a system solution that was superior in quality to other systems in the marketplace. To accomplish this goal the decision was made to employ only local manufacture to maximize the quality of the finished product. In an attempt to save cost, some of the other notable aeration manufacturers have moved their manufacturing to low cost foreign suppliers at the cost of quality. You can be assured that the Aquarius product is Made In The USA and is the highest quality system on the market.

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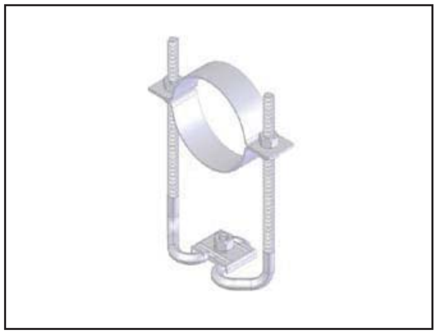
PRODUCT IMPROVEMENTS

The following is a brief summary of the product improvements and components details of the Aquarius system.

AQUARIUS THREADED UNION JOINT

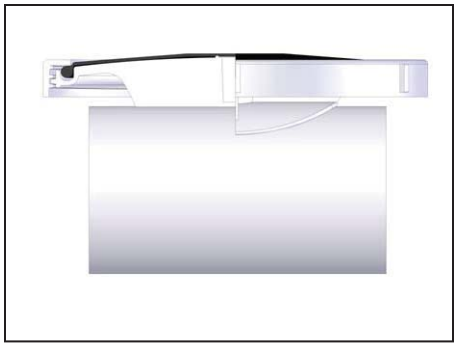
- Greater threaded profile and thicker retainer ring resulting in a stronger more reliable joint
- Sealing O-ring is compressed on 4 sides vs. 2 sides resulting in greater sealing force
- Anti-rotation feature with infinite angular rotation and reduced joint stress

AQUARIUS AIR DISTRIBUTOR GUIDE SUPPORT



- Single anchor bolt design for lateral adjustment provides for ease of installation
- Non-binding design for pipe expansion/contraction reduces stress concentration in the piping and support
- Lower clamp bolt elevation uniform throughout grid provides for ease of installation
- Infinite elevation adjustment within limits of the support provides for installation with sloped tank floors
- All guide type supports up to 80’ distributor length minimizes the use of underwater expansion joints
- Bi-directional design minimizes installation error
- Locating plate locks support in position

AQUARIUS DIFFUSER HOLDER

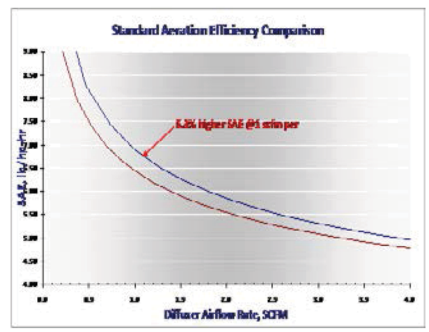


- Low profile, factory bonded design results in increased diffuser submergence
- Greater holder to pipe contact area increases bonding force
- Square ring and holder threads allow for full, non-point contact thereby increasing sealing force

AQUARIUS DIFFUSER

- 9” diameter interchangeable with competitors holders
- Proprietary EPDM based compound
- 10% less extractable oil ensures long term diffuser life through increased molecular stability
- 19% percent improved uniformity of air distribution provides for improved oxygen transfer efficiency

AQUARIUS PERFORMANCE



- Greater than 5% OTE enhancement yields $14/diffuser ownership advantage at $0.07/kWh or 35% less diffusers for same BHP expended

We feel very confident in the design, manufacturing and performance of our system and believe that the Aquarius system will provide the customer with the most cost effective and highest performing aeration system on the market today.

TECHNOLOGIES INC.

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EVALUATION CONSIDERATIONS

1. Suggested Diffuser Layouts

Below is the basis of design utilized in the evaluation. Aquarius has proposed two diffuser layout alternatives delivering the specified AOR with the specified process parameters and distribution. The first alternative is a high efficiency system which minimizes airflow rate per diffuser and increases diffuser density in order to maximize oxygen transfer efficiency, which does come at a higher capital cost however. The second alternative is a standard efficiency system which moderates the airflow rate per diffuser and diffuser density to produce an efficient system but at reduced capital cost. We suggest consideration of both depending on the needs of the City, however assuming a reasonable energy cost of $0.10/kwh, the high efficiency alternative would recoup the additional capital cost through operational savings at the current average loading in approximately 3 years.

Number of Basins:	4
Number of Zones per Basin:	6
Length per Zone (ft):	53.0
Width per Zone (ft):	53.0
Liquid Depth (ft):	17.0

Design Parameters	**Current Avg**	**Future Avg**	**Current Max**	**Future Max**
Actual Oxygen Req'd (lbs/d):	50,000	70,000	90,000	126,000
Alpha:	0.55	0.55	0.55	0.55
Beta:	0.95	0.95	0.95	0.95
Theta:	1.024	1.024	1.024	1.024
Dissolved Oxygen (mg/l):	2.0	2.0	1.0	1.0
Waste Temperature (^{0}C):	30	30	30	30
Elevation (ft):	25	25	25	25

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System Taper

Zone 1:	32%
Zone 2:	28%
Zone 3:	20%
Zone 4:	10%
Zone 5:	6%
Zone 6:	4%

Below are tables indicating diffuser quantity per zone, quantity of air distributors, distributor spacing, support spacing and drop pipe sizes. The proposed systems have been designed to utilize existing drop pipe locations and piping diameters to seamlessly retrofit the existing system.

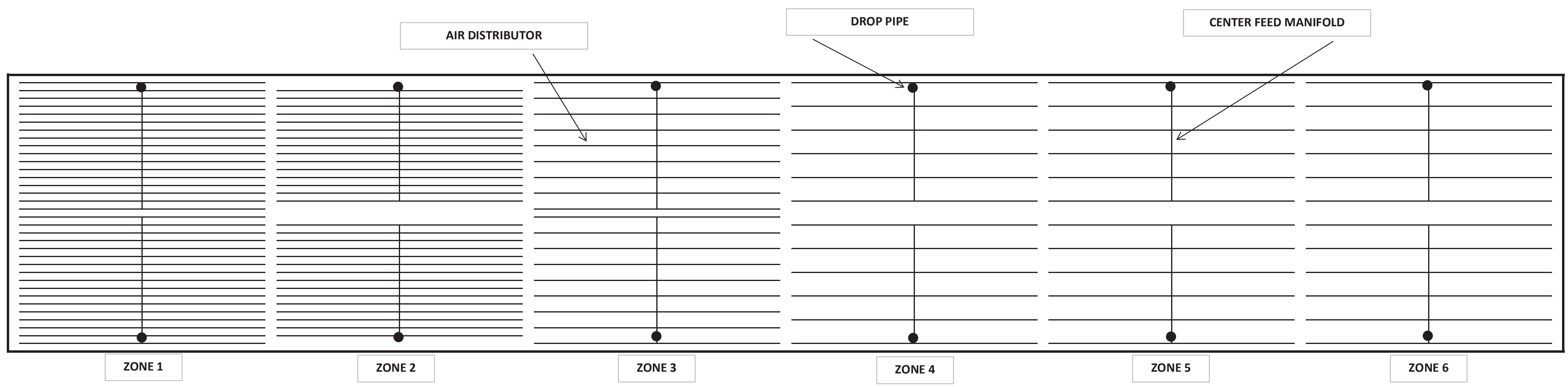
High Efficiency Option –

DAR Zone	# of Grids/ Zone	# of Diffuser/ Zone	# of Air Dist./ Zone	Air Dist. Spac. (in.)	# of Diff./ Air Distributor	Support Spac. (ft.)**(1)**	Drop Pipe Dia. (in.) **(2)**	Total Diffuser #
1	2	850	17	18	50	5’	8	6,800
2	2	750	12	26	50	5’	10	6,000
3	2	550	11	29	50	5’	8	4,400
4	2	276	6	48	46	7.5’	8	2,208
5	2	175	6	48	29	7.5’	6	1,400
6	2	120	6	48	20	7.5’	6	960
								21,768

(1) 5’ support spacing required in zones with mixers, 7.5’ maximum spacing in zones without mixers

(2) Drop pipe diameter matches existing.

(3) Pipe joints installed at 20’ spacing maximum.


AIR DISTRIBUTOR
DROP PIPE
CENTER FEED MANIFOLD
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6

Standard Efficiency Option –

DAR Zone	# of Grids/ Zone	# of Diffuser/ Zone	# of Air Dist./ Zone	Air Dist. Spac. (in.)	# of Diff./ Air Distributor	Support Spac. (ft.)**(1)**	Drop Pipe Dia. (in.) **(2)**	Total Diffuser #
1	2	576	12	26	48	5’	8	4,608
2	2	500	10	30	50	5’	10	4,000
3	2	350	7	45	50	5’	8	2,800
4	2	192	6	48	32	7.5’	8	1,536
5	2	120	6	48	20	7.5’	6	960
6	2	84	6	48	14	7.5’	6	672
								14,576

(4) 5’ support spacing required in zones with mixers, 7.5’ maximum spacing in zones without mixers

(5) Drop pipe diameter matches existing.

(6) Pipe joints installed at 20’ spacing maximum.

2. Design Data

Below is a table which summarizes the key system performance parameters of the proposed aeration systems. In support of this tabulated data, attached are detailed calculations for each DAR Zone which indicates basis of design, system operating parameters along with headloss and SOTE curves.

High Efficiency System Performance

			Cur Avg	Fut Avg	Cur Max	Fut Max
Overall Summary						
Total Number Diffusers		21768				
Total Number Grids		48				
Number Trains in Operation			24	24	24	24
Total Aerated Volume	ft3		1146072	1146072	1146072	1146072
Total AOR	lbs-O2/d		50000	70000	90000	126000
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		122085	170916	189793	265707
Total Air Rate	SCFM		13219	19251	21642	31519
Diffuser Air Rate	SCFM/diff		0.61	0.88	0.99	1.45
SOTE			36.86%	35.43%	35.00%	33.65%
Max Dropleg Pressure	Psig		7.42	7.46	7.48	7.58
Zone 1						
Total Number Diffusers		6800				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		16,000	22,400	28,800	40,320
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		39,070	54,693	60,735	85,027
Total Air Rate	SCFM		4,176	6,075	6,827	9,933
Diffuser Air Rate	SCFM/diff		0.61	0.89	1.00	1.46
SOTE			37.34%	35.93%	35.50%	34.16%
Max Dropleg Pressure	Psig		7.42	7.46	7.48	7.57
Zone 2						
Total Number Diffusers		6000				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		14,000	19,600	25,200	35,280
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		34,183	47,856	53,141	74,398
Total Air Rate	SCFM		3,660	5,324	5,984	8,706
Diffuser Air Rate	SCFM/diff		0.61	0.89	1.00	1.45
SOTE			37.28%	35.87%	35.45%	34.11%
Max Dropleg Pressure	Psig		7.42	7.45	7.46	7.54
Zone 3						
Total Number Diffusers		4400				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		10,000	14,000	18,000	25,200
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		24,416	34,183	37,958	53,141
Total Air Rate	SCFM		2,627	3,822	4,296	6,251
Diffuser Air Rate	SCFM/diff		0.60	0.87	0.98	1.42
SOTE			37.10%	35.69%	35.27%	33.93%
Max Dropleg Pressure	Psig		7.42	7.45	7.46	7.54
Zone 4						
Total Number Diffusers		2208				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		5,000	7,000	9,000	12,600
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		12,208	17,093	18,979	26,570
Total Air Rate	SCFM		1,351	1,969	2,213	3,225
Diffuser Air Rate	SCFM/diff		0.61	0.89	1.00	1.46
SOTE			36.06%	34.65%	34.22%	32.88%
Max Dropleg Pressure	Psig		7.41	7.45	7.46	7.54
Zone 5						
Total Number Diffusers		1400				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		3,000	4,200	5,400	7,560
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		7,325	10,255	11,387	15,942
Total Air Rate	SCFM		831	1,216	1,368	2,000
Diffuser Air Rate	SCFM/diff		0.59	0.87	0.98	1.43
SOTE			35.16%	33.67%	33.22%	31.81%
Max Dropleg Pressure	Psig		7.41	7.44	7.46	7.53
Zone 6						
Total Number Diffusers		960				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		2,000	2,800	3,600	5,040
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		4,883	6,837	7,592	10,628
Total Air Rate	SCFM		574	845	953	1,404
Diffuser Air Rate	SCFM/diff		0.60	0.88	0.99	1.46
SOTE			33.96%	32.29%	31.78%	30.22%
Max Dropleg Pressure	Psig		7.42	7.46	7.48	7.58

Standard Efficiency System Performance

			Cur Avg	Fut Avg	Cur Max	Fut Max
Overall Summary						
Total Number Diffusers		14576				
Total Number Grids		48				
Number Trains in Operation			24	24	24	24
Total Aerated Volume	ft3		1146072	1146072	1146072	1146072
Total AOR	lbs-O2/d		50000	70000	90000	126000
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		122082	170915	189791	265707
Total Air Rate	SCFM		14104	20572	23138	33753
Diffuser Air Rate	SCFM/diff		0.97	1.41	1.59	2.32
SOTE			34.55%	33.16%	32.74%	31.42%
Max Dropleg Pressure	Psig		7.46	7.54	7.58	7.78
Zone 1						
Total Number Diffusers		4608				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		16,000	22,400	28,800	40,320
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		39,066	54,693	60,733	85,027
Total Air Rate	SCFM		4,406	6,411	7,205	10,484
Diffuser Air Rate	SCFM/diff		0.96	1.39	1.56	2.28
SOTE			35.39%	34.05%	33.64%	32.37%
Max Dropleg Pressure	Psig		7.46	7.54	7.57	7.76
Zone 2						
Total Number Diffusers		4000				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		14,000	19,600	25,200	35,280
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		34,183	47,856	53,142	74,397
Total Air Rate	SCFM		3,876	5,640	6,339	9,225
Diffuser Air Rate	SCFM/diff		0.97	1.41	1.58	2.31
SOTE			35.20%	33.86%	33.46%	32.19%
Max Dropleg Pressure	Psig		7.46	7.53	7.56	7.74
Zone 3						
Total Number Diffusers		2800				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		10,000	14,000	18,000	25,200
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		24,416	34,184	37,958	53,142
Total Air Rate	SCFM		2,815	4,099	4,608	6,709
Diffuser Air Rate	SCFM/diff		1.01	1.46	1.65	2.40
SOTE			34.61%	33.28%	32.88%	31.61%
Max Dropleg Pressure	Psig		7.46	7.54	7.58	7.77
Zone 4						
Total Number Diffusers		1536				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		5,000	7,000	9,000	12,600
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		12,208	17,091	18,979	26,571
Total Air Rate	SCFM		1,449	2,117	2,382	3,479
Diffuser Air Rate	SCFM/diff		0.94	1.38	1.55	2.27
SOTE			33.61%	32.22%	31.80%	30.48%
Max Dropleg Pressure	Psig		7.45	7.52	7.55	7.72
Zone 5						
Total Number Diffusers		960				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		3,000	4,200	5,400	7,560
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		7,325	10,255	11,387	15,942
Total Air Rate	SCFM		915	1,347	1,520	2,238
Diffuser Air Rate	SCFM/diff		0.95	1.40	1.58	2.33
SOTE			31.95%	30.38%	29.91%	28.43%
Max Dropleg Pressure	Psig		7.45	7.53	7.56	7.74
Zone 6						
Total Number Diffusers		672				
Total Number Grids		8				
Number Trains in Operation			4	4	4	4
Total Aerated Volume	ft3		191,012	191,012	191,012	191,012
Total AOR	lbs-O2/d		2,000	2,800	3,600	5,040
AOR/SOR			0.410	0.410	0.474	0.474
Total SOR	lbs-O2/d		4,883	6,837	7,592	10,628
Total Air Rate	SCFM		642	957	1,084	1,617
Diffuser Air Rate	SCFM/diff		0.96	1.42	1.61	2.41
SOTE			30.36%	28.50%	27.95%	26.23%
Max Dropleg Pressure	Psig		7.46	7.53	7.57	7.78

5. System Construction

In addition to information contained in Section I which describes system construction and design, attached is additional information pertaining to the construction of the proposed system. Details are as follows:

- Material and manufacturing specifications
- Diffuser quality control plan
- Piping system component details
- Pipe jointing details
- Diffuser holder details

As it relates to the use of piping system supports, in the zones that will have the influence of mixers, ½" diameter minimum rod air distributor supports will be utilized at 5' spacing along with struts as necessary. In zones without mixers, 3/8" diameter minimum rod air distributor supports will be utilized at 7'-6" maximum spacing.

With regard to air distributor and manifold wall thickness, due to the indicated concerns the City Staff has had with thin wall PVC piping (SDR 33.5), we recommend Sch. 40 wall minimum or Sch. 80 for even greater impact resistance. The budgetary proposal indicates the associated cost of each.

Relative to stainless steel material, either 304L or 316L stainless steel is available. The budgetary proposal indicates the associated cost of each.

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AQUARIUS TECHNOLOGIES INC.

MEMBRANE DISC FINE BUBBLE AERATION SYSTEM (304 STAINLESS STEEL)

Component	Material Specification	Manufacturing Specification	Note
Dropleg - Upper	304L Stn. Stl. - ASTM A240	Pipe / Tube - ASTM A - 778 Fittings - ASTM A - 774 Cleaning - ASTM A - 380	
Supports	304 Stn. Stl. - ASTM A240 Threaded Rod - ASTM A276 Sheet / Plate - ASTM A240		"L" grade not required for non-welded parts "L" grade required for welded parts
Bolts, Nuts, Washers	18-8 Stn. Stl.		
Dropleg - Lower	PVC - ASTM D1784 Compound - 12454-B	Pipe - ASTM D1785 Fittings - ASTM D2466	
Manifold (6" & Larger Diameter)	PVC - ASTM D1784 Compound - 12454-B	Pipe - ASTM D1785 Fittings - ASTM D2466	
Manifold (4" Diameter)	PVC - ASTM D3915 Compound - 124524	Pipe - ASTM D3034 Fittings - ASTM D3034	Minimum 2% Titanium Dioxide
Header	PVC - ASTM D3915 Compound - 124524	Pipe - ASTM D3034 Fittings - ASTM D3034	Minimum 2% Titanium Dioxide
Diffuser Holder, Retainer Ring	PVC - ASTM D3915 Compound - 124524		Minimum 2% Titanium Dioxide
Union Joint	PVC - ASTM D3915 Compound - 124524	Pipe - ASTM D3034 Fittings - ASTM D3034	Minimum 2% Titanium Dioxide
PVC Solvent Glue	ASTM 2564	ASTM D2855	
Union Joint O-Ring	Natural Rubber / SBR		45 +/- Durometer Shore A
Diffuser Element	EPDM		

AQUARIUS
TECHNOLOGIES INC.

MEMBRANE DISC FINE BUBBLE AERATION SYSTEM (316 STAINLESS STEEL)

Component	Material Specification	Manufacturing Specification	Note
Dropleg - Upper	316L Stn. Stl. - ASTM A240	Pipe / Tube - ASTM A - 778 Fittings - ASTM A - 774 Cleaning - ASTM A - 380	
Supports	316 Stn. Stl. - ASTM A240 Threaded Rod - ASTM A276 Sheet / Plate - ASTM A240		"L" grade not required for non-welded parts "L" grade required for welded parts
Bolts, Nuts, Washers	316 Stn. Stl.		
Dropleg - Lower	PVC - ASTM D1784 Compound - 12454-B	Pipe - ASTM D1785 Fittings - ASTM D2466	
Manifold (6" & Larger Diameter)	PVC - ASTM D1784 Compound - 12454-B	Pipe - ASTM D1785 Fittings - ASTM D2466	
Manifold (4" Diameter)	PVC - ASTM D3915 Compound - 124524	Pipe - ASTM D3034 Fittings - ASTM D3034	Minimum 2% Titanium Dioxide
Header	PVC - ASTM D3915 Compound - 124524	Pipe - ASTM D3034 Fittings - ASTM D3034	Minimum 2% Titanium Dioxide
Diffuser Holder, Retainer Ring	PVC - ASTM D3915 Compound - 124524		Minimum 2% Titanium Dioxide
Union Joint	PVC - ASTM D3915 Compound - 124524	Pipe - ASTM D3034 Fittings - ASTM D3034	Minimum 2% Titanium Dioxide
PVC Solvent Glue	ASTM 2564	ASTM D2855	
Union Joint O-Ring	Natural Rubber / SBR		45 +/- Durometer Shore A
Diffuser Element	EPDM		

1103 Mineral Springs Drive, Port Washington, WI 53074
Tel: 262-268-1500 Fax: 262-268-1515
www.aquariustechnologies.com

<u>Aquarius Technologies Membrane Disc Diffuser</u>
<u>Quality Control Test Requirements</u>

Step 1.
<u>Primary QC, Secondary Test:</u> Manufacturing Quality Control will be performed at the manufacturers, prior to perforation.
<u>Step 2.</u>
Performance Quality Control will be performed at the manufacturers, after perforation.

<u>Step 1.</u>
<u>Primary</u> <u>Durometer - 58 +/- 5%, Shore A, per ASTM 2240</u>

Primary Sampling Criteria
Specification - Military Standard 105D

Table 1 - Sampling size and code letter information

- Lot or Batch size 3,201 to 10,000
- Primary test general inspection level II
- Primary test sample size code letter L

Table III-A - Double sampling plan information

- Primary test sample size code letter L
- Primary test sample size, 125 units each, 2 samples per batch
- Primary test AQL level 1.5

Primary Test Acceptance Criteria

Sample 1(125 units)

- If 3 or less units are found defective, the entire batch is accepted and no further testing is required.
- If 4,5 or 6 units are found to be defective, sample 2 must be tested.
- If 7 or more units are found defective in the first sample the batch is rejected.

The Manufacturer, at their option, may test from the rejected batch and furnish those units that are found to be within the acceptable criteria.

Sample 2 (125 units)

- If a cumulative total of 8 units from sample 1 and sample 2 are found to be defective, the entire batch is accepted and no further testing is required.
- If a cumulative total of 9 units from sample 1 and sample 2 are found to be defective, the entire batch is rejected.

The Manufacturer, at their option, may test from the rejected batch and furnish those units that are found to be within the acceptable criteria.

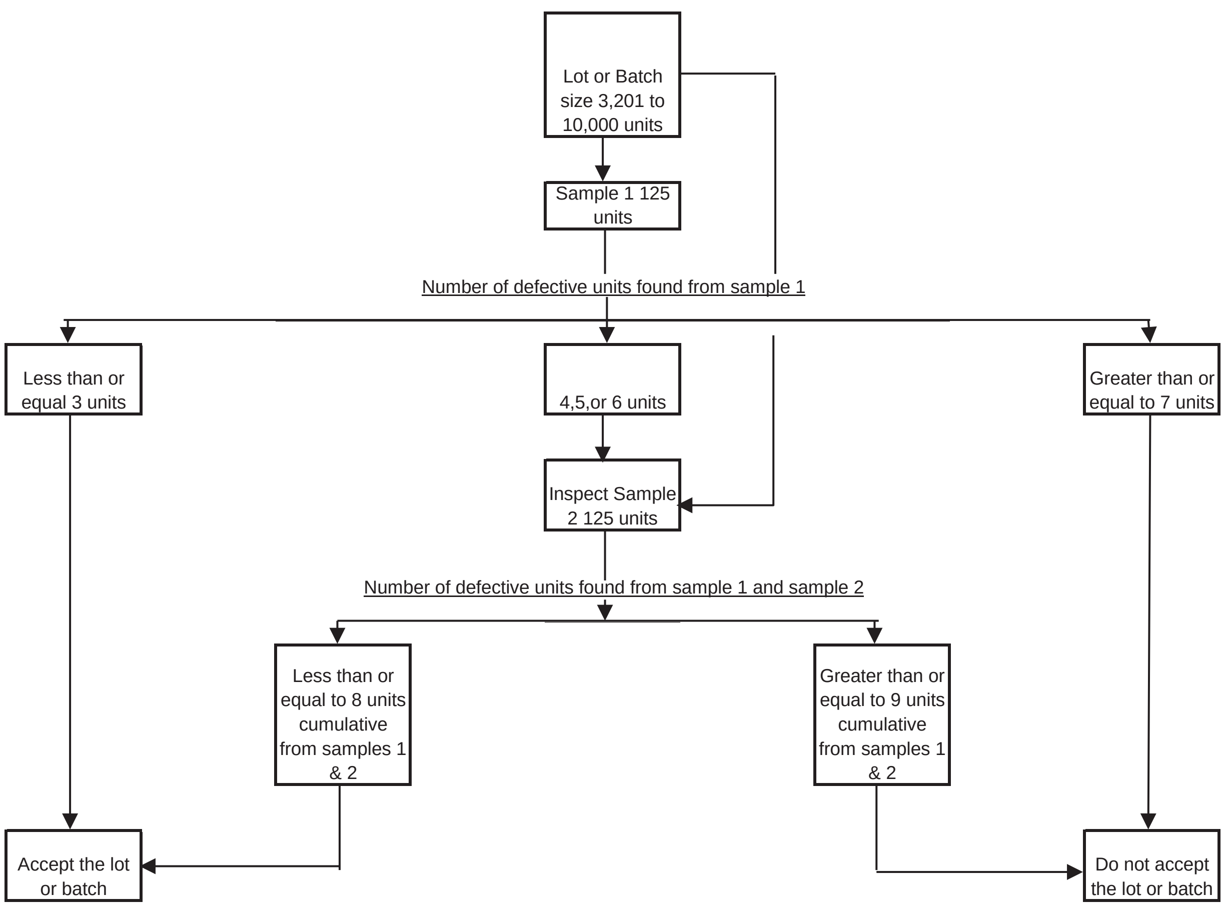
Aquarius Technologies Membrane Disc Diffuser
Quality Control Test Requirements

Manufacturing Quality Control will be performed at the manufacturers, prior to perforation.

Primary Durometer - 58 +/- 5%, Shore A, per ASTM 2240

Primary Sampling Criteria
Specification - Military Standard 105D
Table 1 - Sampling size and code letter information
- Lot or Batch size 3,201 to 10,000
- Primary test general inspection level II
- Primary test sample size code letter L

Table III-A - Double sampling plan information
- Primary test sample size code letter L
- Primary test sample size, 125 units each, 2 samples per batch
- Primary test AQL level 1.5



The Manufacturer, at their option, may test from the rejected batch
and furnish those units that are found to be within the acceptable criteria.

Aquarius Technologies Membrane Disc Diffuser
Quality Control Test Requirements

Secondary **Tensile Strength - 1200 PSI per ASTM D412**
Minimum Moduleas of Elasticity - 500 PSI per ASTM D 412
Specific Gravity - 1.10 +/- 5%

Table 1 - Sampling size and code letter information
- Secondary test general inspection level S-2
- Secondary test sample size code letter D

Table III-A - Double sampling plan information
- Primary test sample size code letter D
- Primary test sample size, 5 units each, 2 samples per batch. Secondary test samples to be taken from primary sample test lot.
- Primary test AQL level 6.5

Secondary Test Acceptance Criteria

Sample 1(5 units)
- If 0 units are found defective, the entire batch is accepted and no further testing is required.
- If 1 unit is found to be defective, sample 2 must be tested.
- If 2 or more units are found defective in the first sample the batch is rejected.

The Manufacturer, at their option, may test from the rejected batch and furnish those units that are found to be within the acceptable criteria.

Sample 2 (5 units)
- If a cumulative total of 1 unit from sample 1 and sample 2 are found to be defective, the entire batch is accepted and no further testing is required.
- If a cumulative total of 2 units from sample 1 and sample 2 are found to be defective, the entire batch is rejected.

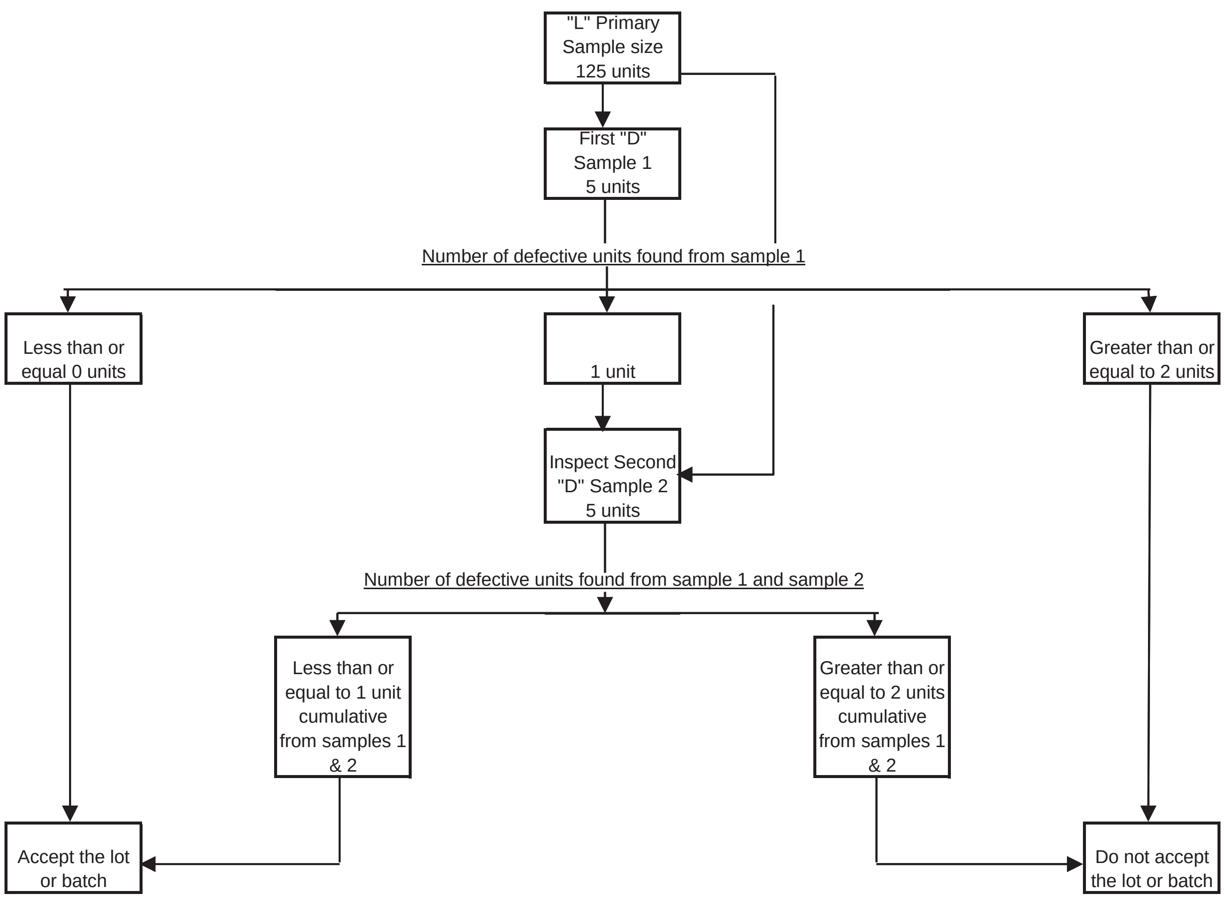
The Manufacturer, at their option, may test from the rejected batch and furnish those units that are found to be within the acceptable criteria.

Aquarius Technologies Membrane Disc Diffuser
Quality Control Test Requirements

Secondary **Tensile Strength - 1200 PSI per ASTM D412**
Minimum Modulas of Elasticity - 500 PSI per ASTM D 412
Specific Gravity - 1.10 +/- 5%

Table 1 - Sampling size and code letter information
- Secondary test general inspection level S-2
- Secondary test sample size code letter D

Table III-A - Double sampling plan information
- Primary test sample size code letter D
- Primary test sample size, 5 units each, 2 samples per batch. Secondary test samples to be taken from primary sample test lot.
- Primary test AQL level 6.5



The Manufacturer, at their option, may test from the rejected batch and furnish those units that are found to be within the acceptable criteria.

Aquarius Technologies Membrane Disc Diffuser
Quality Control Test Requirements

Aquarius Technologies Part # MBD-90001-E

Step 2.

Performance Quality Control will be performed at the manufacturers, after perforation of the Membrane Disc.

Dynamic Wet Pressure (DWP)

- 9" Diameter Membrane: 9.6" - 14.4" w.c. @ 1.0 SCFM per diffuser.
- One diffuser per 25 shall be tested for DWP.

Air Flow Uniformity -

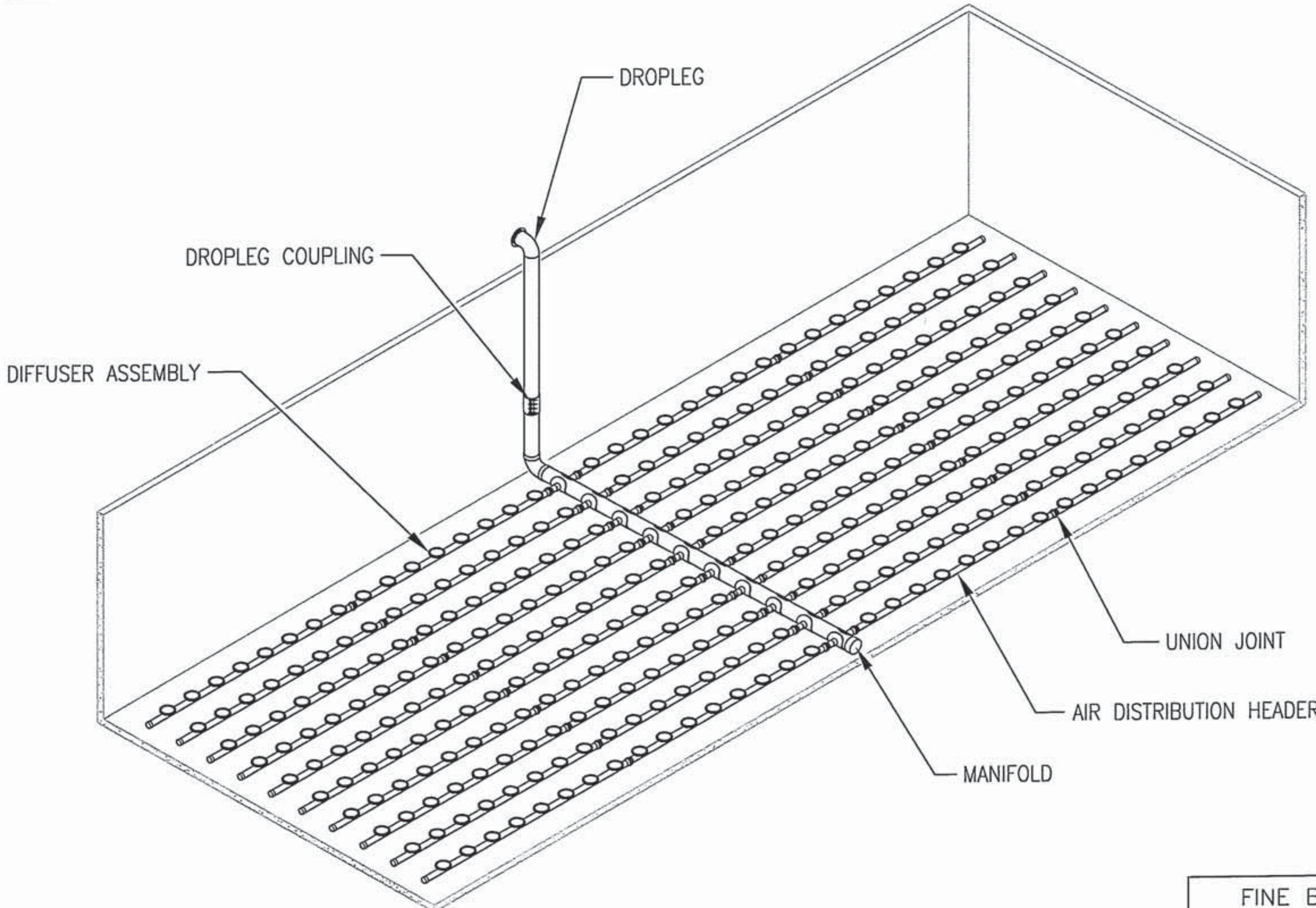
Is a visual inspection to verify substantially uniform air distribution when the diffuser is submerged and operated at:

- 0.5, 0.75, 1.0 SCFM per diffuser.
- One diffuser per 25 shall be tested for DWP.

Aquarius Technologies Membrane Disc Diffuser

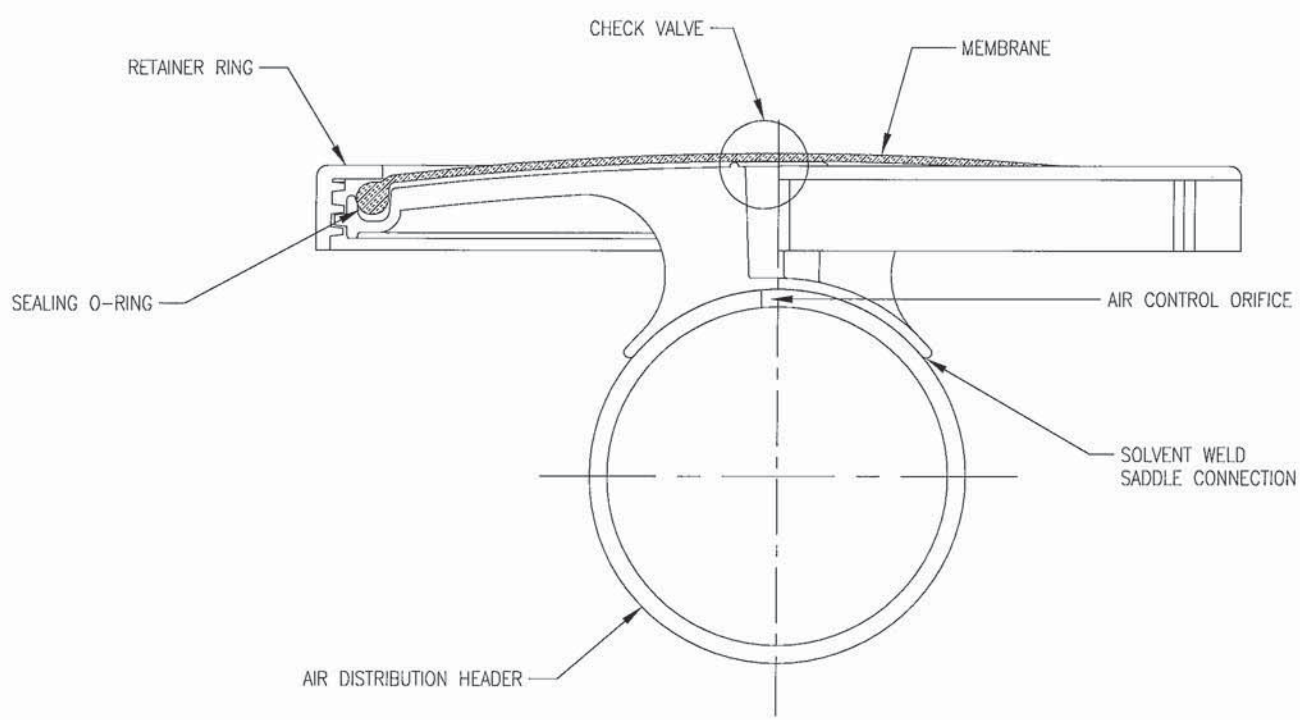
Aquarius Technologies Part # MBD-90001-E

Material Properties	**Value / Units**	**Test Procedure**
Base Compound	EPDM with Carbon Black for UV Protection	----------
Tensile Strength (unperforated)	1,200 PSI / Min.	ASTM D412
Elongation at break	350% Min.	ASTM D412
Hardness (Durometer)	58+/-5, Shore A	ASTM 2240
Accelerated Aging Compression Set (Under constant deflection) 22 Hrs. @ 70 deg. C	40% Max.	ASTM D3935 Test Method A
Accelerated Aging Elongation (% Retained) 70 Hrs. @ 100 deg. C	75% Max.	ASTM D573
Ozone Resistance 72Hrs., 40 deg C, 50 pphm	No cracks @ 2X Magnification	ASTM D1171 Method A
Modulus @ 300%	500 PSI / Min.	ASTM D412
Dynamic Wet Pressure	9.6" - 14.4" w.c.	@ 1.0 scfm @ 2" W.C.
Nominal Diameter	9"	----------
Active Surface Area	0.41 sq.ft.	----------
Material Thickness	0.080"	----------
Check Value Leakage Rate	0 ml H20 after 48 hours unpressurized	



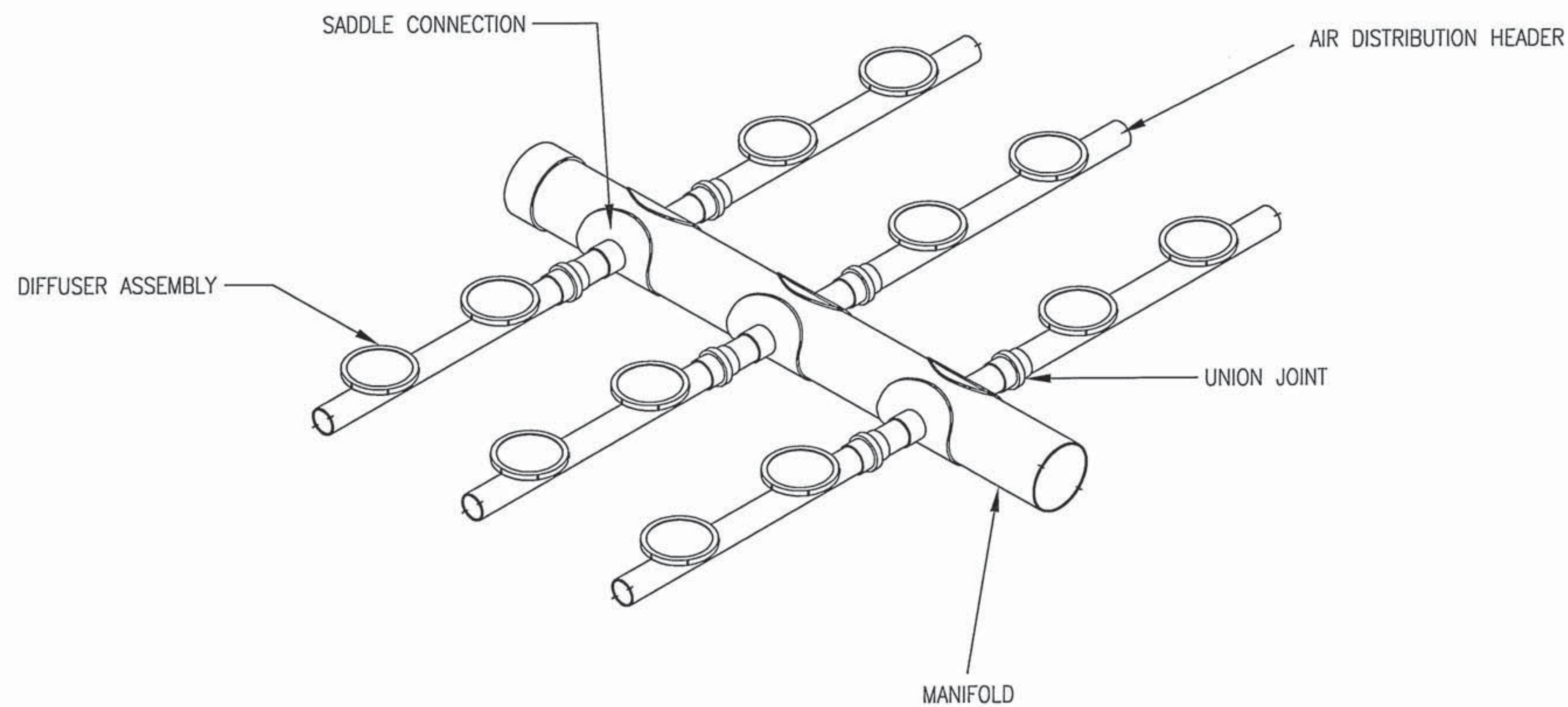
FINE BUBBLE AERATION SYSTEM CENTER FEED MANIFOLD

AQUARIUS TECHNOLOGIES, INC.



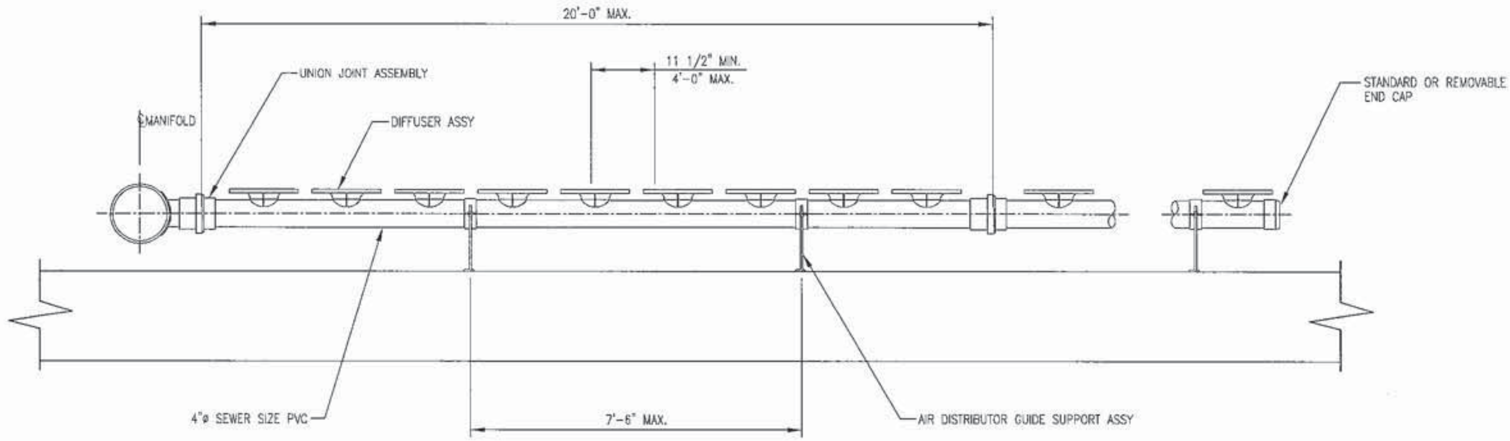
FINE BUBBLE
MEMBRANE DIFFUSER
ASSEMBLY

AQUARIUS
TECHNOLOGIES, INC.



FINE BUBBLE AERATION
CENTER FEED MANIFOLD

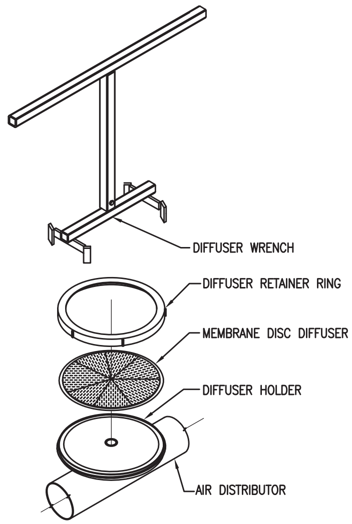
AQUARIUS
TECHNOLOGIES, INC.



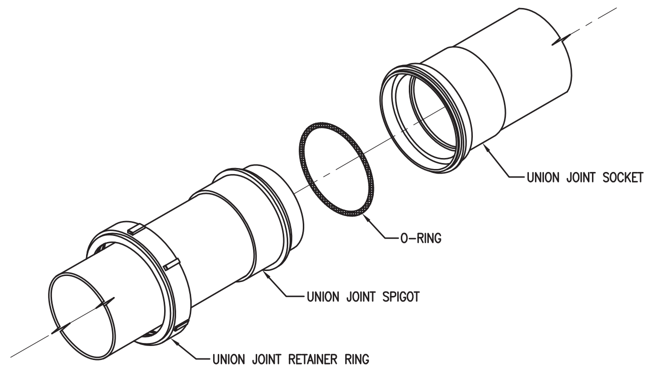
TYPICAL HEADER SECTION

FINE BUBBLE AERATION SYSTEM
TYPICAL HEADER

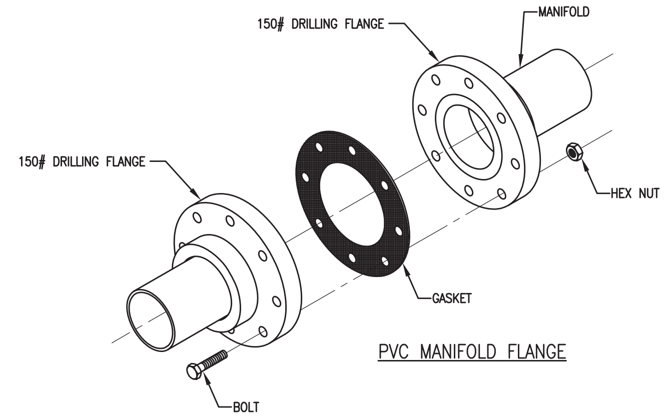
AQUARIUS TECHNOLOGIES, INC.



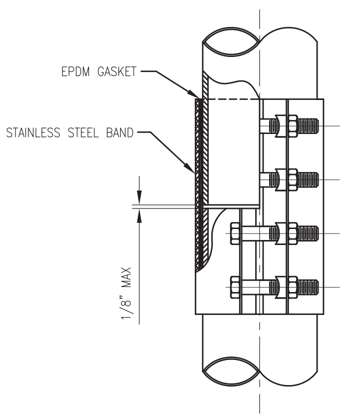
MEMBRANE DISC DIFFUSER ASSEMBLY



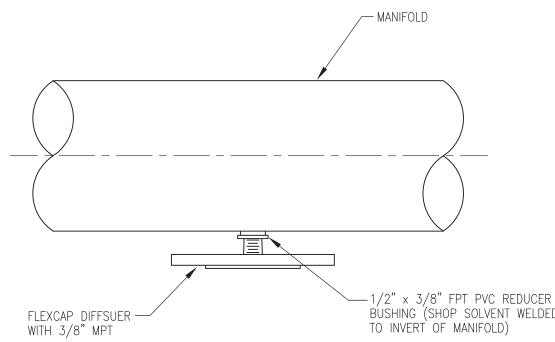
UNION JOINT ASSEMBLY



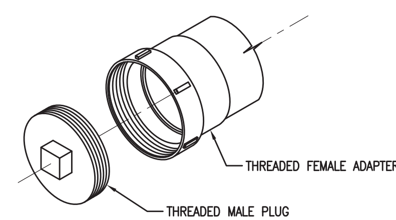
PVC MANIFOLD FLANGE



CLAMP COUPLING



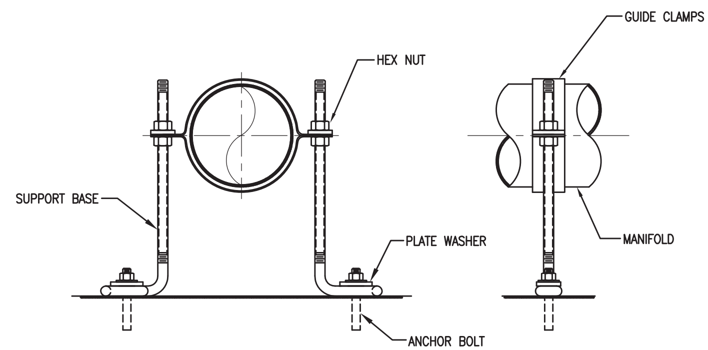
CONTINUOUS PURGE ASSEMBLY



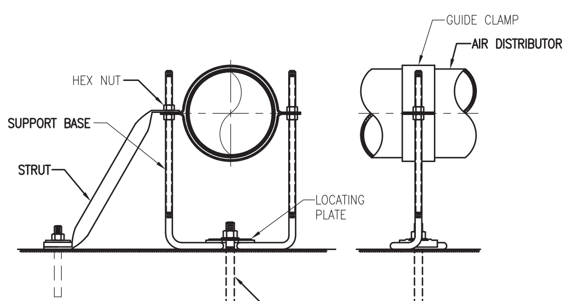
AIR DISTRIBUTOR REMOVABLE END CAP

FINE BUBBLE AERATION SYSTEM
COMPONENT DETAILS

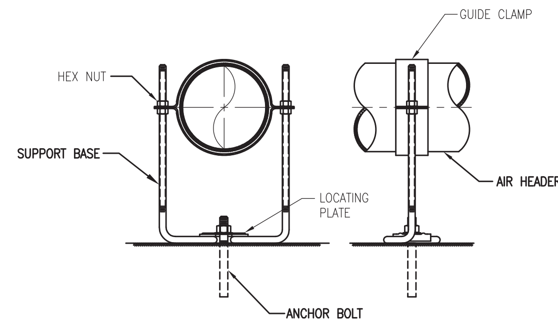
AQUARIUS
TECHNOLOGIES, INC.



MANIFOLD SUPPORT ASSEMBLY



AIR DISTRIBUTOR GUIDE SUPPORT ASSEMBLY
WITH STRUT



AIR DISTRIBUTOR GUIDE SUPPORT ASSEMBLY

FINE BUBBLE AERATION SYSTEM
COMPONENT DETAILS

AQUARIUS
TECHNOLOGIES, INC.

6. Estimated Service Life

As noted in Section I the Aquarius membrane has a proprietary EPDM based compound that has 10% less extractable oil than similar type diffusers. This will result in a more chemically stable diffuser thereby providing longer life. The life and performance of a membrane diffuser is dependent on the environment in which it is operating. Some wastewaters are more aggressive to membrane diffusers than others. Our experience has provided us the opportunity of analyzing environments that are especially aggressive toward membrane materials. By focusing on these environments, we are able to understand and analyze how the membrane diffuser element ages with time in service and how this affects diffuser life. By concentrating on these points, we were able to develop the advanced EPDM recipe that is our membrane diffuser. The Aquarius membrane will provide a longer duty of service and at a higher level of efficiency. The cost associated with replacing units sooner and incurring additional power charges should be considered when purchasing equipment. While it is impossible to predict how a specific wastewater will affect the Aquarius membrane diffuser, we can state with confidence that the diffuser life will be longer than other disk diffusers and likely be on the order of 10 years. The decision to replace diffusers will be one of economics, whereby replacing the diffusers to a new, more efficient one, will result in a relatively short payback through energy savings. Below is a partial list of competitors EPDM diffusers which have been replaced by Aquarius.

Smurfit-Stone Container Ontonagon, MI	11,550 Membrane Diffusers	Craig Mackey (906) 884-7292
Weyerhaeuser Company Longview, WA	10,750 Membrane Diffusers	Carla Beckstrom
Anacortes, WA	500 Membrane Diffusers	John Franz (360) 299-0953
Tlayacapan & Jamay, MX	800 Membrane Diffusers	Constance Okhuysen 0011523336860733
Glendale, AZ	4,500 Membrane Diffusers	Earl Babcock (623) 930-2863
Tomahawk, WI	350 Membrane Diffusers	Eric Martin (715) 453-3143
Fort Atkinson, WI	910 Membrane Diffusers	Michael Paul (920) 563-7766
Prescott, WI	450 Membrane Diffusers	Thomas Early (715) 262-5544

7. Estimated System Cost

The budgetary cost proposal and options for alternative materials is contained in the following Section III.

8. Estimated Replacement Cost

Currently the cost of a replacement membrane disc diffuser is $3.00 and we would expect up to a 10% increase in cost over the next 20 years. Over a 20 year optional period we would expect the City to replace diffusers after each 10 year operational period. The balance of the system is designed for a 30 year life; however minor components could become damaged in operation due to impacts through cleaning or dropping of foreign objects on the system. We would expect the value of these parts to be insignificant. Individual component parts prices are as follows:

Diffuser Holder	$3.50
Diffuser Retainer Ring	$2.25
Air Distributor Support	$12.00
Air Distributor Section w/ Diffuser Holders	$150.00
Air Distributor Union Joint	$10.00
Air Distributor Repair Coupling	$3.00
Manifold Saddle	$85.00

1103 Mineral Springs Drive, Port Washington, WI 53074
Tel: 262-268-1500 Fax: 262-268-1515
WWW.AQUARIUSTECHNOLOGIES.COM

9. References - We offer the following installation contacts for your consideration, as well as a list of projects are contained in Section IV of the proposal.

Project	Diffuser Qty	Contact	Engineer
Region of Peel G.E. Booth WWTP, ON	23,000	William Fernandes (905) 274-9616 x131	KMK/AECOM
Hampton Roads Sanitary District, Nansemond, VA	20,850	Bill Balzer (757) 638-7361	Hazen & Sawyer
Meriden, CT	8,000	Dennis Waz (203) 630-4261	Metcalf & Eddy/AECOM
Collier County, FL	14,560	Jon Pratt (239) 252-5355	Hazen & Sawyer
Harker Heights, TX	10,368	Bruce Sorenson (254) 702-6780	Aqua Aerobic Systems
Atlantic Beach, FL	3,976	Troy Stephens (904) 247-5842	John Collins Engineering
Greeley, CO	15,000	Ted Vogel (970) 350-9360	Brown & Caldwell

10. Visitations – Installations at Collier County NCWRF, Atlantic Beach and Eustis are all moderately sizeable installations and could compare to the Tampa DAR Project. We believe TSC Jacobs could arrange site visits for the City Staff as necessary.

AQUARIUS
TECHNOLOGIES INC.

3

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www.aquariustechnologies.com

AQUARIUS TECHNOLOGIES INC.

DATE: **JANUARY 14, 2013**

TO: **THE CITY OF TAMPA, FL**

RE: **TAMPA DAR PROJECT**
PROPOSAL NO. 4115-13

ENGINEER: **TETRA TECH**

Aquarius is pleased to provide a budgetary proposal for the following equipment and services in order to ensure provision of a complete, integrated, diffused aeration system.

A. EQUIPMENT – HIGH EFFICIENCY ALTERNATIVE

Aquarius will provide forty-eight (48) fine bubble aeration systems with 21,768 diffusers for installation in Reactors 1 – 4 as follows:

Aeration Grid	Drop Pipe Dia. (in.)	Qty of Grids	Qty of Diffusers
Grid Type 1	8	8	6,800
Grid Type 2	10	8	6,000
Grid Type 3	8	8	4,400
Grid Type 4	8	8	2,208
Grid Type 5	6	8	1,400
Grid Type 6	6	8	960

Each Fine Bubble Aeration System will consist of the following:

- One (1) 10’ long 12 ga. 304L stainless steel drop pipe including flange for connection to the existing drop pipe and a connection to the manifold at the bottom.
- One (1) 20’ long Sch. 40 PVC manifold with a connection to the drop pipe and air distributors.
- Required 50’ long 4” diameter Sch. 40 wall PVC air distributors with a connection to the manifold and factory installed diffuser holders.
- Required PVC pipe joint connections.
- Required 304 stainless steel piping supports with vertical supports, clamps, adjusting mechanism and 304 stainless steel anchor bolts.
- Required fine bubble diffuser assemblies.
- Required 304 stainless steel bolts, nuts and gaskets for field assembly.
- Air lift eductor style condensate purge system.

AQUARIUS TECHNOLOGIES INC.

B. FACTORY OXYGEN TRANSFER TEST

Aquarius will perform a shop oxygen transfer shop test at GSEE in Laverne, TN. Test includes:

- Use of 20' diameter x 20' SWD Aeration Test Tank
- All water and chemicals
- Test probes, pressure and air gauges
- Aeration system
- Oxygen transfer testing
- Written test report

C. FIELD SERVICES

Aquarius will provide twelve (12) days of service for installation inspection, performance testing, equipment start-up, and operator training as required. Additional field service is available at a cost of $950.00/day plus travel, lodging, and meal expenses.

D. AQUARIUS EXCLUSIONS

Aquarius excludes the following from its proposal:

- Field installation of equipment.
- Gaskets, bolts and nuts for connecting drop pipes to air main.

E. PRICING – HIGH EFFICIENCY ALTERNATIVE

Net sell price for the Aquarius Equipment as described above, FOB jobsite:

High Efficiency Alternative: **$ 590,000**

Optional Sch. 80 PVC Piping: $ **40,000**

Optional 316L SS vs. 304L SS: $ **15,000**

F. EQUIPMENT – STANDARD EFFICIENCY ALTERNATIVE

Aquarius will provide forty-eight (48) fine bubble aeration systems with 14,576 diffusers for installation in Reactors 1 – 4 as follows:

Aeration Grid	Drop Pipe Dia. (in.)	Qty of Grids	Qty of Diffusers
Grid Type 1	8	8	4,608
Grid Type 2	10	8	4,000
Grid Type 3	8	8	2,800
Grid Type 4	8	8	1,536
Grid Type 5	6	8	960
Grid Type 6	6	8	672

Each Fine Bubble Aeration System will consist of the following:

- One (1) 10' long 12 ga. 304L stainless steel drop pipe including flange for connection to the existing drop pipe and a connection to the manifold at the bottom.
- One (1) 20' long Sch. 40 PVC manifold with a connection to the drop pipe and air distributors.
- Required 50' long 4" diameter Sch. 40 wall PVC air distributors with a connection to the manifold and factory installed diffuser holders.
- Required PVC pipe joint connections.
- Required 304 stainless steel piping supports with vertical supports, clamps, adjusting mechanism and 304 stainless steel anchor bolts.
- Required fine bubble diffuser assemblies.
- Required 304 stainless steel bolts, nuts and gaskets for field assembly.
- Air lift eductor style condensate purge system.

G. FACTORY OXYGEN TRANSFER TEST

Aquarius will perform a shop oxygen transfer shop test at GSEE in Laverne, TN. Test includes:

- Use of 20' diameter x 20' SWD Aeration Test Tank
- All water and chemicals
- Test probes, pressure and air gauges
- Aeration system
- Oxygen transfer testing
- Written test report

H. FIELD SERVICES

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I. AQUARIUS EXCLUSIONS

Aquarius excludes the following from its proposal:

- Field installation of equipment.
- Gaskets, bolts and nuts for connecting drop pipes to air main.

J. PRICING – STANDARD EFFICIENCY ALTERNATIVE

Net sell price for the Aquarius Equipment as described above, FOB jobsite:

Standard Efficiency Alternative: **$ 480,000**

Optional Sch. 80 PVC Piping: $ **35,000**

Optional 316L SS vs. 304L SS: $ **12,500**

AQUARIUS TECHNOLOGIES INC.

FINE BUBBLE AERATION EQUIPMENT PARTIAL PROJECT LIST

Project	Location	Diffuser Quantity	Equipment Type	Engineer
Glendale, AZ	AZ	4,500	Membrane Disc Diffuser Elements	City of Glendale
Kingman, AZ	AZ	418	Membrane Disc Diffuser System	Brown & Caldwell
Gainey Ranch, AZ	AZ	1,147	Membrane Disc Diffuser System	Valentine Env. Eng.
Goodyear - Corgett WRF, AZ	AZ	420	Membrane Disc Diffuser System	Tata & Howard
Riverside, CA	CA	4,940	Membrane Disc Diffuser System	Aqua Engineering
Camp Pendleton, CA	CA	3,024	Membrane Disc Diffuser System	CDM
Goleta, CA	CA	900	Membrane Disc Diffuser System	HDR
Marin County #5, CA	CA	466	Membrane Disc Diffuser System	Carollo
Colborne, ON	CANADA	420	Membrane Disc Diffuser System	Genivar, Inc.
Region of Peel - Clarkson WWTP, ON	CANADA	21,200	Membrane Disc Diffuser System	AECOM
Hagersville, ON	CANADA	1,584	Membrane Disc Diffuser System	Hatch Mott MacDonald
Region of Peel - G.E. Booth WWTP, ON	CANADA	23,000	Membrane Disc Diffuser System	KMK/AECOM
Kelowna, BC	CANADA	7,100	Membrane Disc Diffuser System	Stantec Consulting Ltd.
Leamington, ON	CANADA	6,200	Ceramic Disc w/ Gas Cleaning	CH2M Hill
McCain Foods Canada, Carberry, MB	CANADA	3,840	Membrane Disc Diffuser System	AMEC Geomatrix
Komoka, ON	CANADA	624	Membrane Disc Diffuser System	Stantec
Mississippi Mills, ON	CANADA	3,646	Membrane Disc Diffuser System	Thompson Rosemount
Strathmore, AB	CANADA	1,845	Membrane Disc Diffuser System	Maple Reinders
Arnprior, ON	CANADA	1,536	Membrane Disc Diffuser System	J.L. Richards
Drumheller, AB	CANADA	1,374	Membrane Disc w/ Exist. Ceramic Gas Cleaning	Stantec
Cascades Paper – Kingsey Falls, QC	CANADA	900	Membrane Disc Diffuser System	Cascades
Kleinburg, ON	CANADA	540	Membrane Disc Diffuser System	Conestoga Rovers
Taber, AB	CANADA	762	Membrane Disc Diffuser System	Stantec Consulting Ltd.
Craigleith, ON	CANADA	684	Membrane Disc Diffuser System	City Staff
Canadian Forces Base , 8Wing - Trenton, ON	CANADA	368	Membrane Disc Diffuser System	Canadian Gov.
Town of Blue Mountains, ON	CANADA	228	Membrane Disc Diffuser System	Town of Blue Mountains
Great Blue Heron Casino, ON	CANADA	312	Membrane Disc Diffuser System	CH2M Hill
Merrick Landfill, ON	CANADA	16	Membrane Disc Diffuser System	CRA
Bancroft, ON	CANADA	520	Membrane Disc Diffuser System	Stantec
Amherstburg, ON	CANADA	1,280	Membrane Disc Diffuser System	CH2M Hill
Hawkesbury, ON	CANADA	286	Membrane Disc Diffuser System	Thompson Rosemount
Dutton, ON	CANADA	280	Membrane Disc Diffuser System	Dillon Consulting
McCain Foods Canada, Grand Falls, NB	CANADA	500	Ceramic Diffuser Elements	McCain Foods
McCain Foods Canada, Grand Falls, NB	CANADA	556	Ceramic Diffuser Elements	McCain Foods
Brantford, ON	CANADA	4,620	Ceramic Disc Diffuser System	RV Anderson
Kitchener WWT Plant 1, ON	CANADA	8,464	Membrane Disc Diffuser System	AECOM
North Grenville, ON	CANADA	40	Ceramic Diffuser Elements	City Staff
Region of Waterloo, ON	CANADA	9,536	Membrane Disc Diffuser System	AECOM
Canada Malting, AB	CANADA	4,000	Membrane Disc Diffuser System	GE Water
North Grenville, ON	CANADA	600	Ceramic Diffuser Elements	City Staff
Shenyang, China	CHINA	1,250	Membrane Disc Diffuser Elements	Teijin Ltd.
Greeley, CO	CO	15,034	Ceramic Disc Diffuser System	Brown & Caldwell
Glenwood Springs, CO	CO	1,440	Membrane Disc Diffuser System	SGM
Platte Canyon School District, CO	CO	50	Membrane Disc Diffuser System	Laughlin Rincon
City of Brush, CO	CO	1,444	Ceramic Disc w/ Gas Cleaning	Stantec
Town of Mancos, CO	CO	360	Membrane Disc Diffuser System	Souder Miller
Meriden, CT	CT	8,000	Membrane Disc Diffuser System	M&E/AECOM
Southbury, CT	CT	1,100	Membrane Disc Diffuser System	Weston & Sampson
Putnam, CT	CT	1,005	Membrane Disc Diffuser System	Fuss & O'Neill
Key Largo, FL	FL	600	Membrane Disc Diffuser System	Wade Trim
Collier County - NCWRF, FL	FL	4,212	Membrane Disc Diffuser System	Hole Montes/Hazen & Sawyer
City of Atlantic Beach, FL	FL	3,472	Membrane Disc Diffuser System	J. Collins Engineering
City of Atlantic Beach, FL	FL	504	Membrane Disc Diffuser System	J. Collins Engineering
Collier County - NCWRF, FL	FL	4,960	Membrane Disc Diffuser Elements	City Staff
Collier County - NCWRF, FL	FL	5,388	Membrane Disc Diffuser Elements	City Staff
Hunters Ridge, FL	FL	218	Membrane Disc Diffuser System	Hole Montes
Eustis, FL	FL	2,995	Membrane Disc Diffuser System	Tetra Tech
Cocoa Beach, FL	FL	180	Membrane Disc Diffuser System	Quentin L. Hampton
Dade City, FL	FL	420	Membrane Disc Diffuser System	Baskerville Donovan
Lafayette, GA	GA	162	Membrane Disc Diffuser System	Sweitzer Engineering
F. Wayne Hill - Gwinnett County, GA	GA	400	Membrane Disc Diffuser System	Hazen & Sawyer
Reynolds, GA	GA	648	Membrane Disc Diffuser System	Carter & Sloope
GE Water – Bellevue, ID	ID	624	Membrane Disc Diffuser System	Keller Associates
American Falls, ID	ID	1,054	Membrane Disc Diffuser System	Keller Associates
Filer, ID	ID	680	Membrane Disc Diffuser System	JUB
Teton Valley Regional WWTP, ID	ID	1,296	Membrane Disc Diffuser System	Aqua Engineering
Rexburg, ID	ID	1,300	Membrane Disc Diffuser Elements	City Staff
Centralia, IL	IL	56	Membrane Disc Diffuser System	Engineered Fluid
Forreston, IL	IL	346	Membrane Disc Diffuser System	Fehr Grahm
Milledgeville, IL	IL	308	Membrane Disc Diffuser System	Doonan Environmental
Marengo, IL	IL	90	Membrane Disc Diffuser System	McMahon Associates

AQUARIUS TECHNOLOGIES INC.

FINE BUBBLE AERATION EQUIPMENT PARTIAL PROJECT LIST

Project	Location	Diffuser Quantity	Equipment Type	Engineer
Depue, IL	IL	85	Membrane Disc Diffuser System	Chamlin & Associates
Mill Creek, IL	IL	1,768	Membrane Disc Diffuser System	AECOM
Thompson, IL	IL	460	Membrane Disc Diffuser Elements	City Staff
Pekin, IL	IL	1,827	Membrane Disc Diffuser System	Farnsworth Group
Mill Creek WRF - Lake County, IL	IL	500	Membrane Disc Diffuser Elements	County Staff
Green County, IN	IN	141	Membrane Disc Diffuser Elements	Foresight Engineering
Green County, IN	IN	6	Ceramic Disc Diffuser Elements	Foresight Engineering
Dana, IN	IN	256	Membrane Disc Diffuser System	Commonwealth
Darlington, IN	IN	96	Membrane Disc Diffuser System	B.L. Anderson
Jennings Northern Regional Utility, IN	IN	480	Membrane Disc Diffuser System	Commonwealth
Mexico, IN	IN	12	Membrane Disc Diffuser System	Commonwealth
Patriot, IN	IN	59	Membrane Disc Diffuser System	Strand Associates
Sharon Laboratories Ltd., Israel	ISRAEL	432	Membrane Disc Diffuser System	CTG Ltd.
Kohav Shahar, Israel	ISRAEL	274	Membrane Disc Diffuser System	Iz-Har Ltd.
Maale Mihmash, Israel	ISRAEL	190	Membrane Disc Diffuser System	Iz-Har Ltd.
Lachish, Israel	ISRAEL	502	Membrane Disc Diffuser System	CTG Ltd.
Dodge City, KS	KS	936	Membrane Disc Diffuser System	PEC
Tortilla King - Moundridge, KS	KS	96	Membrane Disc Diffuser System	Tortilla King
Williamstown, KY	KY	24	Membrane Disc Diffuser System	HDR
Flemingsburg, KY	KY	40	Membrane Disc Diffuser System	HDR
Young Cheong, South Korea	KOREA	1,390	Membrane Disc Diffuser System	EcoOne
Sung Seo, South Korea	KOREA	4,602	Membrane Disc Diffuser System	EcoOne
Harvey, LA	LA	312	Membrane Disc Diffuser System	Digital Engineering
Ellsworth, ME	ME	832	Membrane Disc Diffuser System	Woodward & Curran
Augusta, ME	ME	96	Membrane Disc Diffuser System	City Staff
Mystic Harbour, MD	MD	756	Membrane Disc Diffuser System	JMT
Newburyport, MA	MA	3,480	Membrane Disc Diffuser System	Weston & Sampson
Clinton, MA	MA	1,218	Membrane Disc Diffuser System	Fay, Spofford & Thorndike
Teotihuacan, MX	MEXICO	948	Membrane Disc Diffuser System	Fypasa
Chilpancingo, MX	MEXICO	3,288	Membrane Disc Diffuser System	Fypasa
San Jeronimo, MX	MEXICO	3,456	Membrane Disc Diffuser System	Fypasa
Leon, Mexico	MEXICO	11,466	Membrane Disc Diffuser System	Fypasa
Aguasblancas, Acapulco, MX	MEXICO	19,164	Membrane Disc Diffuser System	Fypasa
Monterrey – Noreste, MX	MEXICO	9,552	Membrane Disc w/ Gas Cleaning	Domos
Tlajomulco, MX	MEXICO	5,910	Membrane Disc Diffuser System	Geminis
Veracruz, MX	MEXICO	2,702	Membrane Disc Diffuser System	ISSASA
Minera Fresnillo, MX	MEXICO	1,773	Membrane Disc Diffuser System	ISSASA
Zapotlan el Grande, MX	MEXICO	1,527	Membrane Disc Diffuser System	Corporacion POK
El Salto Durango, Mexico	MEXICO	371	Membrane Disc Diffuser System	ISSASA
San Antonio Tlayacapan, Jalisco, MX	MEXICO	510	Membrane Disc Diffuser System	Corporacion POK
Jamay, Jalisco, MX	MEXICO	290	Membrane Disc Diffuser System	Corporacion POK
San Luis Soyatlan, MX	MEXICO	348	Membrane Disc Diffuser System	Insamex
Valle de Bravo, MX	MEXICO	3,196	Membrane Disc Diffuser System	Fypasa
Metepec, MX	MEXICO	456	Membrane Disc Diffuser System	Fypasa
Los Arcos, MX	MEXICO	1,038	Membrane Disc Diffuser System	Fypasa
El Avelin, MX	MEXICO	1,038	Membrane Disc Diffuser System	Fypasa
San Martin, MX	MEXICO	448	Membrane Disc Diffuser System	ISSASA
Guadalupe Zacatecas, MX	MEXICO	14,320	Membrane Disc Diffuser System	Ingamex
Altta Homes - Leon, MX	MEXICO	624	Membrane Disc Diffuser System	Fypasa
Dos Bocas Oil, MX	MEXICO	24	Membrane Disc Diffuser System	Dos Bocas Oil
Chimalistac, MX	MEXICO	808	Membrane Disc Diffuser System	Fypasa
Smurfit-Stone Container - Ontonagon, MI	MI	11,550	Membrane Disc Diffuser Elements	Smurfit-Stone Container
Albion, MI	MI	700	Membrane Disc Diffuser System	Tetra Tech
Verso Paper Corp., Quinnesec, MI	MI	7,910	Membrane Disc Diffuser System	Midwest Water Management
Braham, MN	MN	82	Membrane Disc Diffuser System	BDM
O' Fallon, MO	MO	996	Membrane Disc Diffuser System	Donohue & Associates
Union, MO	MO	266	Membrane Disc Diffuser System	Cochran Engineering
St. Louis, MO Missouri River Plant	MO	11,490	Membrane Disc Diffuser System	Black & Veatch
Columbia Falls, MT	MT	608	Membrane Disc Diffuser System	HDR
Wayne, NE	NE	1,152	Membrane Disc Diffuser System	JEO Consulting
Hastings, NE	NE	2,151	Membrane Disc Diffuser System	HDR
Skillman Village, NJ	NJ	192	Membrane Disc Diffuser System	AECOM
Taos Valley, NM	NM	5,800	Membrane Disc Diffuser System	Souder Miller
Weedsport, NY	NY	492	Membrane Disc Diffuser System	Barton & Loguidice, P.C.
Waccabuc Country Club, NY	NY	4	Membrane Disc Diffuser System	Malcolm Pirnie
Hauppauge, NY	NY	2,442	Membrane Disc Diffuser System	H2M
Rockbury, NY	NY	672	Membrane Disc Diffuser System	Delaware Engineering
Sanford, NC	NC	3,672	Membrane Disc Diffuser System	Hazen & Sawyer
Hillsboro, OH	OH	160	Membrane Disc Diffuser System	CH2M Hill
Rattlesnake Creek, OH	OH	174	Membrane Disc Diffuser System	HDR
Hamilton, OH	OH	10,820	Ceramic Disc Diffuser System	Burgess & Niple

AQUARIUS TECHNOLOGIES INC.

FINE BUBBLE AERATION EQUIPMENT PARTIAL PROJECT LIST

Project	Location	Diffuser Quantity	Equipment Type	Engineer
Tulsa Southside Plant, OK	OK	22,960	Membrane Disc Diffuser System	Greeley & Hansen
Pendelton, OR	OR	522	Membrane Disc Diffuser System	Kennedy/Jenks
Durham, OR	OR	105	Membrane Disc Diffuser System	West Yost
Dundee, OR	OR	728	Membrane Disc Diffuser System	Kennedy/Jenks
Annville, PA	PA	962	Membrane Disc Diffuser System	Gannett Fleming
Lewistown, PA	PA	2,351	Membrane Disc Diffuser System	Gannett Fleming
Altoona Easterly, PA	PA	7,479	Membrane Disc Diffuser System	Gwyn Dobson & Foreman
Mahoning Township, PA	PA	216	Membrane Disc Diffuser System	Hill Engineering
Carlisle, PA	PA	3,016	Membrane Disc Diffuser System	Black & Veatch
Upper Gwynedd, PA	PA	2,016	Membrane Disc Diffuser System	EEMA
Bloomsburg, PA	PA	1,791	Membrane Disc Diffuser System	Gannett Fleming
Western Butler County Authority, PA	PA	1,050	Membrane Disc Diffuser System	Malcolm Pirnie
Belle Vernon, PA	PA	864	Membrane Disc Diffuser System	Fayette Engineering
New Berlin, PA	PA	332	Membrane Disc Diffuser System	Bassett Engineering
Cambridge Springs, PA	PA	42	Membrane Disc Diffuser System	Hill Engineering
Saint Marys, PA	PA	420	Membrane Disc Diffuser System	City of Saint Marys
Logan Township, PA	PA	324	Membrane Disc Diffuser System	CET Engineering Services
Benner Springs Fish Culture Station, PA	PA	162	Membrane Disc Diffuser System	Maguire Group
Mechanicsburg, PA	PA	2,968	Membrane Disc Diffuser System	Gannett Fleming
Williamsport West Plant, PA	PA	818	Membrane Disc Diffuser System	Gannett Fleming
East Pennsboro Twp., PA	PA	3,924	Membrane Disc Diffuser System	CET Engineering Services
McConnellsburg, PA	PA	634	Membrane Disc Diffuser System	CET Engineering Services
Trails End Camp, PA	PA	135	Membrane Disc Diffuser Elements	EEMA
Springboro, PA	PA	179	Membrane Disc Diffuser System	Deiss & Halmi
Camp Equinunk, PA	PA	240	Membrane Disc Diffuser Elements	EEMA
Germantownship, PA	PA	414	Membrane Disc Diffuser System	Wagner Fluid Systems
Mount Pleasant, SC	SC	3,000	Membrane Disc Diffuser System	Black & Veatch
Charleston - Plum Island WPCP, SC	SC	8,018	Membrane Disc Diffuser System	Hazen & Sawyer
Williamston	SC	10	Membrane Tube Diffuser System	Goldie & Associates
ReWa - Piedmont Regional WWTP, SC	SC	1,946	Membrane Disc Diffuser System	MWH Constructors
Villarin de Campos, Spain	SPAIN	188	Membrane Disc Diffuser System	Elif Iberica
Villalbilla, Spain	SPAIN	546	Membrane Disc Diffuser System	Integra Environmental
Torrealqueria, Spain	SPAIN	72	Membrane Disc Diffuser System	Integra Environmental
Galveston, TX	TX	21,436	Membrane Disc Diffuser System	CDM Smith
Azle, TX	TX	1,028	Membrane Disc Diffuser System	Alan Plummer
Harker Heights, TX	TX	10,368	Membrane Disc Diffuser System	Aqua-Aerobic Systems
Rowlett Creek - Garland, TX	TX	5,200	Membrane Disc Diffuser System	Perkins Engineering
Fort Bend MUD 116, TX	TX	1,888	Membrane Disc Diffuser System	RG Miller
Harris County MUD 16, TX	TX	1,246	Membrane Disc Diffuser System	WAWCON
Fort Bend County, TX	TX	2720	Membrane Disc Diffuser System	Jones & Carter
Woodcreek MUD, TX	TX	880	Membrane Disc Diffuser System	Koehn & Associates
Grand Mission MUD, TX	TX	972	Membrane Disc Diffuser System	Jones & Carter
Midland, TX	TX	280	Membrane Disc Diffuser System	CDM Smith
Springtown, TX	TX	14	Membrane Disc Diffuser System	Freese & Nichols
Pier Road Development, Trinidad	TRINIDAD	102	Membrane Disc Diffuser System	Global Scientific
Orem, UT	UT	6,172	Ceramic Disc Diffuser System	Aqua Engineering
HRSD - Nansemond, VA	VA	20,850	Membrane Disc Diffuser System	Hazen & Sawyer
HRSD – VIP, VA	VA	4,232	Membrane Disc Diffuser System	HRDS
Caroline County, VA	VA	768	Membrane Disc Diffuser System	Reid Engineering
Willapa, WA	WA	966	Membrane Disc Diffuser System	Gray & Osborne, Inc.
Shelton, WA	WA	720	Membrane Disc Diffuser System	H.R. Esvelt Engineering
Anacortes, WA	WA	1,400	Membrane Disc Diffuser Elements	City of Anacortes
Anacortes, WA	WA	700	Membrane Disc Diffuser Elements	City of Anacortes
Omak, WA	WA	196	Membrane Disc Diffuser System	Gray & Osborne, Inc.
Weyerhauser - Longview, WA	WA	10,750	Membrane Disc Diffuser Elements	Weyerhauser
Skokomich Tribe, WA	WA	82	Membrane Disc Diffuser System	Gray & Osborne, Inc.
Edgerton, WI	WI	262	Membrane Disc Diffuser System	Foth
Freedom, WI	WI	414	Membrane Disc Diffuser Elements	City Staff
Milton, WI	WI	1,800	Membrane Disc Diffuser Elements	City Staff
Oconomowoc, WI	WI	54	Membrane Disc Diffuser System	Donohue & Associates
Darlington, WI	WI	850	Membrane Disc Diffuser System	Rubicon Environmental
SCA Tissue, Menasha, WI	WI	2,900	Membrane Disc Diffuser System	Midwest Water Management
Mount Horeb, WI	WI	574	Membrane Disc Diffuser Elements	City Staff
Frito Lay Incorporated - Beloit, WI	WI	820	Membrane Disc Diffuser System	Midwest Water Management
Neenah Menasha, WI	WI	120	Membrane Disc Diffuser Elements	City of Neenah Menasha
Rice Lake, WI	WI	2,280	Ceramic Disc Diffuser System	Applied Technologies
Bush Brothers & Company, WI	WI	1,467	Membrane Disc Diffuser System	Donohue & Associates
Prescott, WI	WI	450	Membrane Disc Diffuser System	City of Prescott
City Forest Corp. – Ladysmith, WI	WI	1,456	Membrane Disc Diffuser System	McMahon Associates
Fredonia, WI	WI	448	Membrane Disc Diffuser System	McMahon Associates
Tomahawk, WI	WI	350	Membrane Disc Diffuser Elements	City Staff

AQUARIUS
TECHNOLOGIES INC.

FINE BUBBLE AERATION EQUIPMENT PARTIAL PROJECT LIST

Project	Location	Diffuser Quantity	Equipment Type	Engineer
Georgia Pacific Corp. - Green Bay, WI	WI	318	Membrane Disc Diffuser System	Georgia Pacific Corp.
Kenosha, WI	WI	300	Ceramic Disc Diffuser Elements	City Staff
Fort Atkinson, WI	WI	910	Membrane Disc Diffuser Elements	City Staff
Walworth County, WI	WI	50	Membrane Disc Diffuser Elements	City Staff
Northern Moraine Utilities, WI	WI	600	Membrane Disc Diffusser System	Foth
Beloit, WI	WI	5,500	Membrane Disc Diffuser Elements	City Staff

TETRA TECH, INC.

ATTACHMENT B
SSI MEMBRANE DISC PROPOSAL
(OPTION 3)

SSI Aeration Inc.
4 Tucker Drive
Poughkeepsie, N.Y. 12603 U.S.A.
Tel: 845-454-8171 Fax: 845-454-8094

Email: info@stamfordscientific.com
www.StamfordScientific.com
Please Visit SSI's blog: blog.stamfordscientific.com

January 22, 2013 File: Tampa DAR (Heyward), Q-012213

Heyward Florida Incorporated gchomic@heywardfl.com
415 Country Club Drive
Winter Park, FL 32789

Ref: Tampa DAR Project – Budget Quotation

Mr. Chomic,

In response to your email and based on the information, SSI is pleased to submit this proposal quotation for the design, manufacture & supply of Aeration Equipment for **Four (4) Reactors** with SSI's AFD270-E (9") Fine bubble disc diffusers with compression molded EPDM membrane c/w Q.C saddle

Design Data:

Parameter	Units	Current		Future	
		Average day	Maximum a day	Average day	Maximum a day
SOR	Lbs/day	50,000	90,000	70,000	126,000
Airflow	SCFM	13,455	20,772	19,864	29,897
Airflow/diffuser	SCFM	±1.98	±1.43	±2.93	±2.05
Diffusers	PCS	11,524	24,748	11,524	24,748
SOTE	%	7.35	7.40	6.97	7.20
Pressure at top of Drop pipe	PSIG	8.35			

Attached are the Preliminary drawings showing general arrangement of diffuser layouts

Scope of supply is complete with all components from the downstream of top connection (±6" above water level) of 304SS drop pipe with SS Vanstone and a galvanized follower loose flange

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Each Reactor is approx. 318' x 53' x 17' (SWD) consists of Six (6) Zones and each zone is supplied with equipment as listed below

Zone	304SS Sch.5 Drop Pipe		PVC Sch.80 Manifold		PVC Sch.80 Headers		AFD270 Fine Bubble Disc diffusers c/w Quick connect Saddle
	Size	Len (ft)	Size	Len (ft)	Size	Len (ft)	
#1	Ø12”	15	Ø12”	45	Ø4”	930	**866**
#2	Ø14”	15	Ø14”	45	Ø4”	1260	**1220**
#3	Ø14”	15	Ø14”	45	Ø4”	1260	**1220**
#4	Ø14”	15	Ø14”	45	Ø4”	1260	**1300**
#5	Ø12”	15	Ø12”	45	Ø4”	860	**867**
#6	Ø12”	15	Ø12”	45	Ø4”	710	**714**

Lot – 304SS supports as required

Lot – PVC coupling c/w SS shears to connect drop pipe sections, to connect manifold sections and to connect header pipes as applicable

Total number of diffusers for One (1) Reactor is (866+1220+1220+1300+867+714) =**6,187**

COMMON FOR ALL REACTORS

Total number of diffuser for Four (4) Reactors (6,187pcs/reactor)*4 reactors = **24,748**

Recommended Spares:

- 52 - AFD270 diffusers
- 100 - Diffusers membranes
- 15- 4” 304SS supports
- 8 - 4” PVC couplings
- 2 sets- Special Tools

Recommended Field Services:

- 12 Days in total in Four (4) Trips

Carriage FOB: Freight cost for Job Site

Total Lot Price (for all listed above).. **$819,825.00**

Optional adder for PTFE coated membranes in place of regular EPDM listed above..**$78,120.00**

(Extended warranty of 5 years after startup or 66 months following shipment (whichever comes earlier) on PTFE membranes. All other components carry SSI’s standard warranty)

Note:

This scope includes stainless steel drop pipes. Howerver if if existing drop pipe are in good condition and can be re used we could offer deduct

GENERAL

- All SS pipe work is cleaned degreased and acid washed following fabrication.
- Piping sections are supplied in 20' lengths maximum and connected at site with PVC couplings
- All SS welding is done in the factory and NO site welding involved in the installation of equipment.
- **Spares**: Included as above
- **Site Services:** Included as above
- SSI diffusers are manufactured under ISO9001
- **Warranty**: Unless otherwise noted SSI's standard warranty/guarantee on the equipment supplied is for 18 months from the date of shipment or 12 months after the startup whichever occurs first. Warranty is valid only when SSI or Its Representative/Associates approve/certify the installation.

PRICES ARE:

1. Valid for **100** days.
2. Taxes **NOT** included.
3. Submittal approvals c/w O & M Manuals – **2-3 weeks** after receipt of P.O and all the information necessary to prepare submittal.
4. Completion and ready to ship**: 12-14 weeks** after receipt of approved submittal.
5. **F.O.B:** Freight cost to job site
6. Manufacturer's Service days are included
7. Scopes do not meet any **ARRA** requirements. Prices subject to change to comply with ARRA requirements.
8. Unless otherwise specified all items are supplied loose for field assembly & Installation. Field assembly, installation and other site work by others.
9. Exclusions:
    - Offloading upon delivery to site
    - All items are supplied loose for field assembly & installation by others.
    - Any items and services not itemized within the above scope of supply.
10. Payment Terms:
    a) For Municipal & Government project in USA –95% net 30 days, balance 5% at the time of startup or 75 days after shipment date whichever comes earlier.
    b) For private jobs 30% with P.O, 30% with submittal approval and 40% at the time of shipment

11. Terms & conditions of Sale: Please refer to the attached Terms and Conditions of Sale, which form an integral part of this proposal.

Payment terms are for reference only and subject to final approval from SSI's a/c department.

If you have any questions or if we can be of further assistance please contact us.

Yours truly,
SSI Aeration Inc.,

Godfrey Pinto (Ext .307) godfrey@stamfordscientific.com

AFD270 DESIGN

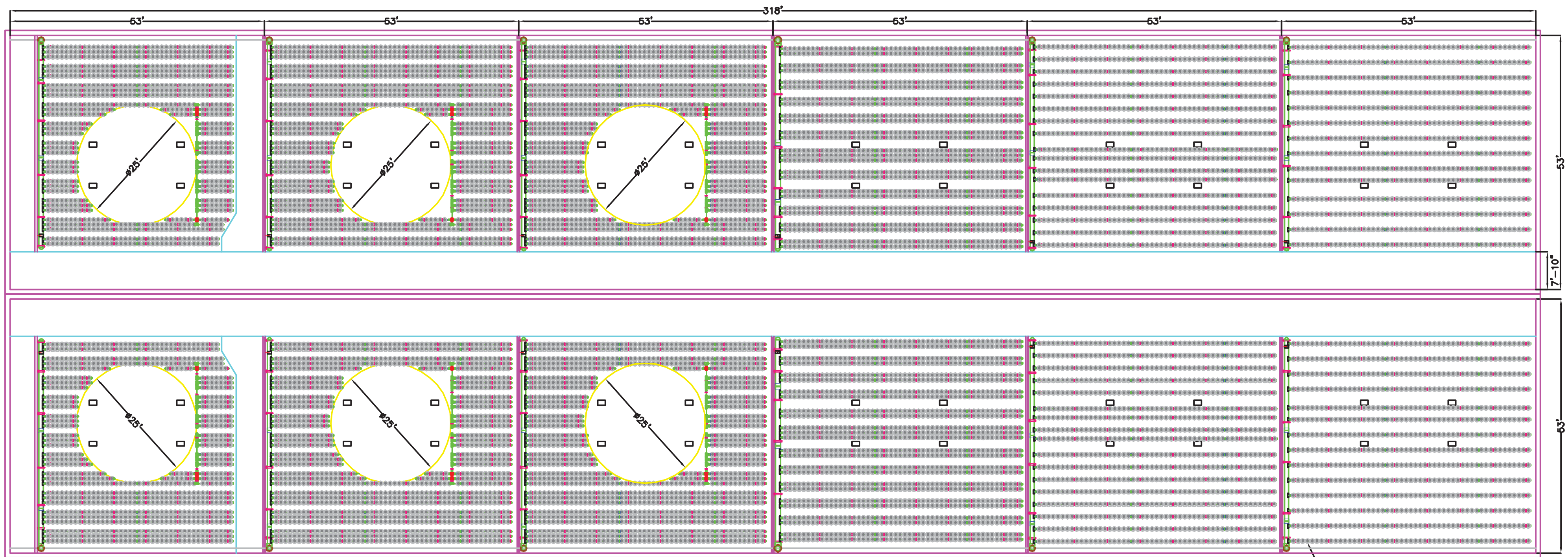
Tampa DAR

Four(4) Aeration Trains

22-Jan-13

AERATION TANK DESIGN	Current		Future	
TANK DESCRIPTION	Ave Day (Swing Zones Diffusers are Turned OFF)	Max day (Swing Zones Diffusers are ON)	Ave Day (Swing Zones Diffusers are Turned OFF)	Max day (Swing Zones Diffusers are ON)
Design Basis (1 BOD, 2 SOR, 3 AOR, 4 COD)	3.00	3.00	3.00	3.00
AOR, Lbs/Day	50,000.00	90,000.00	70,000.00	126,000.00
TSS, mg/l, influent (Not Used in Clalculations)	0.00	0.00	0.00	0.00
TDS, mg/l, influent (For Beta Determination)	0.00	0.00	0.00	0.00
NH3, mg/l, influent	0.00	0.00	0.00	0.00
Barometric Pressure, psia	14.65	14.65	14.65	14.65
Flow, MGD, Raw Influent	56.00	100.80	96.00	172.80
Flow, GPM	38,888.89	70,000.00	66,666.67	120,000.00
Non-Nutrient Excess NH3, mg/l	NA	NA	NA	NA
Additional Nutrient NH3, Reqd, PPD	NA	NA	NA	NA
Non-Nutrient Excess PO4, mg/l	NA	NA	NA	NA
Additional Nutrient PO4, Reqd, PPD	NA	NA	NA	NA
BOD5 Loading, #/day	NA	NA	NA	NA
NH3 Loading, #/day	NA	NA	NA	NA
DESIGN INPUT				
Aeration Time/Day (hrs)	24.00	24.00	24.00	24.00
lb O2/lb BOD5 Required	1.10	1.10	1.10	1.10
lb O2/lb NH3 Required	4.60	4.60	4.60	4.60
MLSS, mg/l	4,000.00	4,000.00	4,000.00	4,000.00
Basin Liquid Depth (ft.)	17.00	17.00	17.00	17.00
Basin Volume, mil. gal.	0.00	0.00	0.00	0.00
AOR Req'd #O2/day	50,000.00	90,000.00	70,000.00	126,000.00
AOR Req'd #O2/hr	2,083.33	3,750.00	2,916.67	5,250.00
O2 Uptake Rate, mg/l/hr	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Basin Volume, mil. lb.	0.00	0.00	0.00	0.00
Basin Volume, Ft³	0.00	0.00	0.00	0.00
Basin Floor Area - Ft²	0.00	0.00	0.00	0.00
Basin Retention Time (d)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Basin Retention Time (hr)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
F/m ratio	NA	NA	NA	NA
Solid Inventory, #TSS	0.00	0.00	0.00	0.00
SOTR CALCULATIONS				
Wastewater Temperature, °C	30.00	30.00	30.00	30.00
Diffuser Water Depth, ft	16.00	16.00	16.00	16.00
Alpha (α) Factor	0.55	0.55	0.55	0.55
Basin DO conc. (Cl), mg/l	2.00	1.00	2.00	1.00
Beta (ß) Factor	0.95	0.95	0.95	0.95
Equivalent Depth Factor	0.35	0.35	0.35	0.35
Theta (Θ) Factor	1.024	1.024	1.024	1.024
C* (surface saturation, Std. Meth.)	7.56	7.56	7.56	7.56
Csw, mg/l, Site Basin Saturation	8.78	8.78	8.78	8.78
Css, mg/l, Std. Basin Saturation	10.59	10.59	10.59	10.59

ß*Csw, mg/l	8.34	8.34	8.34	8.34
Std. O2 Transfer Rate, #O2/day	119,764.14	186,159.67	167,669.79	260,692.90
Std. O2 Transfer Rate, #O2/hr	4,990.17	7,756.65	6,986.24	10,862.20
Std. O2 Transfer Rate, KgO2/hr	2,268.26	3,525.75	3,175.56	4,937.37
KLa20 - /hr	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
DIFFUSER QUANTITY, FLOW & PRESSURE				
Tank Length (ft),(enter 0 if circular)	**636.00**	**1272.00**	**636.00**	**1272.00**
Tank Width (ft), (enter 0 if circular)	**53.00**	**53.00**	**53.00**	**53.00**
Circular Tank Dia, ft (enter 0 if rectangular)	**0.00**	**0.00**	**0.00**	**0.00**
Airflow per diffuser Sm3/hr	**1.98**	**1.43**	**2.93**	**2.05**
SOR IN KG/HR	2268.26	3525.75	3175.56	4937.37
DWD/m	4.88	4.88	4.88	4.88
Normal Conditions in Deg C	**0.00**	**0.00**	**0.00**	**0.00**
Max. ambient temp deg C	**20.00**	**20.00**	**20.00**	**20.00**
Ambient pressure PSIA	**14.70**	**14.70**	**14.70**	**14.70**
Combined motor/blower efficiency	**70%**	**70%**	**70%**	**70%**
OTE/% per m	7.35	7.40	6.97	7.20
Treatment Airflow m3/hr	**22862.24**	**35296.63**	**33752.15**	**50801.45**
Treatment Airflow SCFM	**13454.71**	**20772.50**	**19863.55**	**29897.27**
Diffuser quantity	11524.00	24748.00	11524.00	24748.00
Blower Pressure	6.37	6.37	6.37	6.37
Blower efficiency	65%	65%	65%	65%
WPs HP	501.70	774.56	740.67	1114.81
WPs kW	374.12	577.60	552.33	831.32
grO2/m3	99.21	99.89	94.08	97.19
KgO2/kWh	6.06	6.10	5.75	5.94
Qs/Qs	0.93	0.93	0.93	0.93
Qn	21301.68	32887.31	31448.25	47333.77
Wpa HP	467.45	721.69	690.11	1038.71
Calculated Floor Coverage	14.02%	15.05%	14.02%	15.05%
Circular Tank floor coverage	NA	NA	NA	NA
Minimum Mixing SCFM	**4045**	**8090**	**4045**	**8090**
Comparable Surface Aerator WP a	0	0	0	0
Variance Diff vs S.A. WP a	NA	NA	NA	NA
Cost/kWH of energy, USD	0.15	0.15	0.15	0.15
Cost to run Diffuser system 1 year USD	$442,772	$683,588	$653,676	$983,869
Cost to run Surf. Aer system 1 year USD	$0	$0	$0	$0
Diffuser cost savings/1 year	NA	NA	NA	NA
Diffuser cost savings/10 years	NA	NA	NA	NA
DIFFUSER QUANTITY	**11524**	**24748**	**11524**	**24748**
DIFFUSER AIRFLOW RATE SCFM	**1.17**	**0.84**	**1.72**	**1.21**
TOTAL AIRFLOW in SCFM	**13455**	**20772**	**19864**	**29897**
SOTE %	**35.85%**	**36.10%**	**34.00%**	**35.12%**
PRESSURE in PSIG	**6.37**	**6.37**	**6.37**	**6.37**
DIFFUSER DENSITY	**14.02%**	**15.05%**	**14.02%**	**15.05%**



REACTOR LAYOUT PLAN

TWO(2) SHOWN FOUR(4) REQ'D

ZONE	NUMBER OF ZONE/TANK	NUMBER OF DIFFUSERS/ZONE	DIAMETER OF DROP PIPE (304SS)	DIAMETER OF MANIFOLD (PVC,SCH.80)	DIAMETER OF HEADER (PVC,SCH.80)
#1	1	866PCS	ø12"	ø12"	ø4"
#2	1	1220PCS	ø14"	ø14"	ø4"
#3	1	1220PCS	ø14"	ø14"	ø4"
#4	1	1300PCS	ø14"	ø14"	ø4"
#5	1	867PCS	ø12"	ø12"	ø4"
#6	1	714PCS	ø12"	ø12"	ø4"

TOTAL NUMBER OF DIFFUSERS FOR ONE(1) REACTOR = 6,187 PCS

TOTAL NUMBER OF DIFFUSERS FOR FOUR(4) REACTORS = 24,748 PCS

REV	DESCRIPTION	DATE	BY
0	ISSUED FOR PROPOSAL	01/22/13	KUMAR

SSI AFD270(9") FINE BUBBLE DISC DIFFUSER COMPRESSION MOLDED EPDM MEMBRANES C/W Q.C. SADDLES

CITY OF TAMPA , FLORIDA

REACTOR - 4 NO.S
318' X 53' x 17' (SWD)

LAYOUT PLAN

SSI Aeration,Inc.
CLEAR WATER DEPT.

SUBMITTED:
SCALE:NTS
DATE: JAN, 2013

DESIGNED BY: NOMAN
DRAWN BY: KUMAR
SHEET NO. 1 OF 1

PROPOSAL ISSUE

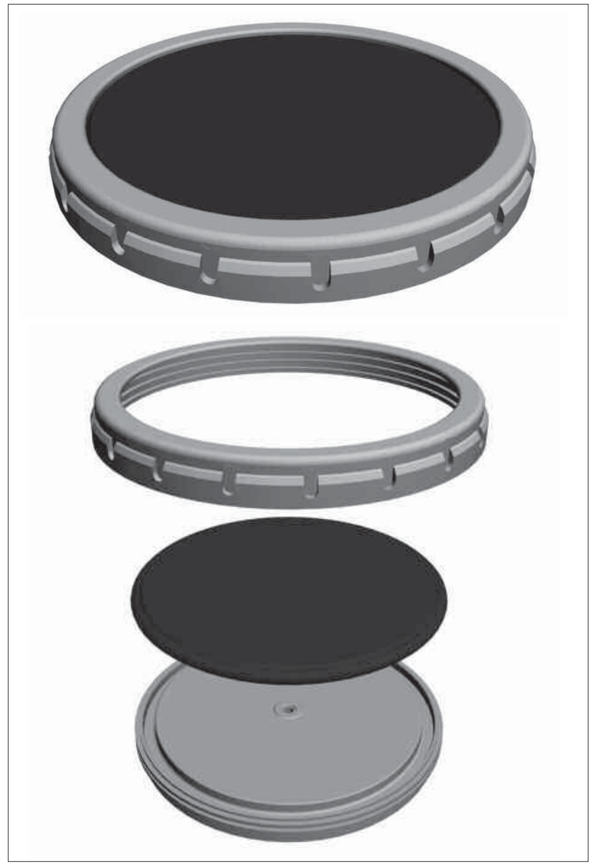
DWG. No. Tampa DAR_Reactor_AFD270_P01

T E C H N I C A L   D A T A   S H E E T

SSI™ FINE BUBBLE DIFFUSERS

AFD270 9" DISC

- Highest possible quality and technology means years of trouble-free efficient operation.
- Highest possible SOTE independently tested per ASCE, and lowest possible headloss.
- Industry Standard Size and Shape. Membranes are interchangeable with (3) other manufacturers.
- Experienced Engineering and Drafting staff with years of practice to assist you.
- Simple and quick installation with QC Saddle or Grommet.
- 212º F (100º C) temperature resistance and environmentally-friendly polypropylene body.
- Compression-molded membranes with individual thermocouples in each cavity = 100% quality control.
- Each membrane checked for even perforation depth to ensure uniform air release.
- Low membrane plasticizer content to reduce shrinkage and hardening, but enough to avoid creep.
- Multiple integral check valves keep your aeration piping system clean.
- 21st century-special materials, such as PTFE, fEPDM, as well as reinforced and coated ultra fine bubble membranes for outstanding chemical or fouling resistance, or for the highest oxygen transfer efficiency at a headloss you can live with.
- In stock on 3 continents in 4 locations.



MEMBRANES

EPDM

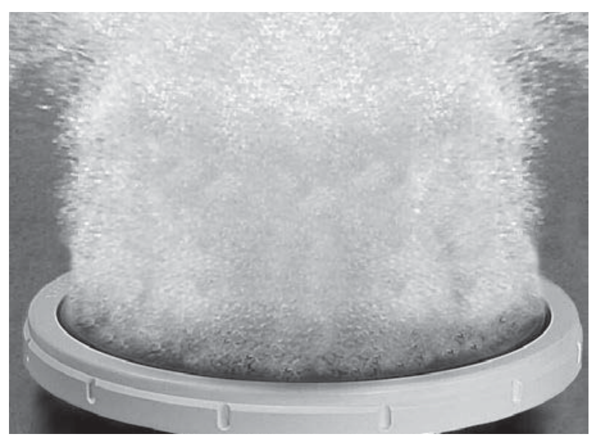
- Excellent conventional material
- No encapsulation

fEPDM

- Superior chemical resistance
- Complete surface and slit encapsulation

PTFE

- Best fouling resistance
- Non-stick coating
- Surface encapsulation



Please see reverse for additional technical data

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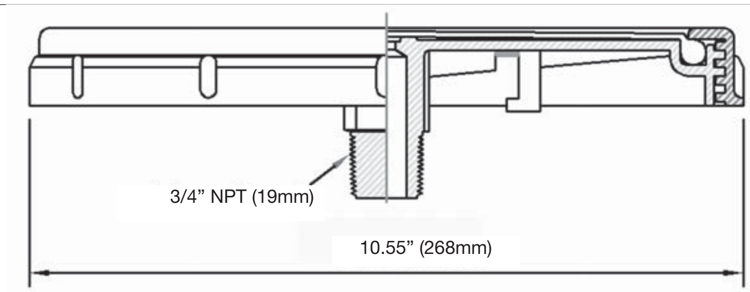
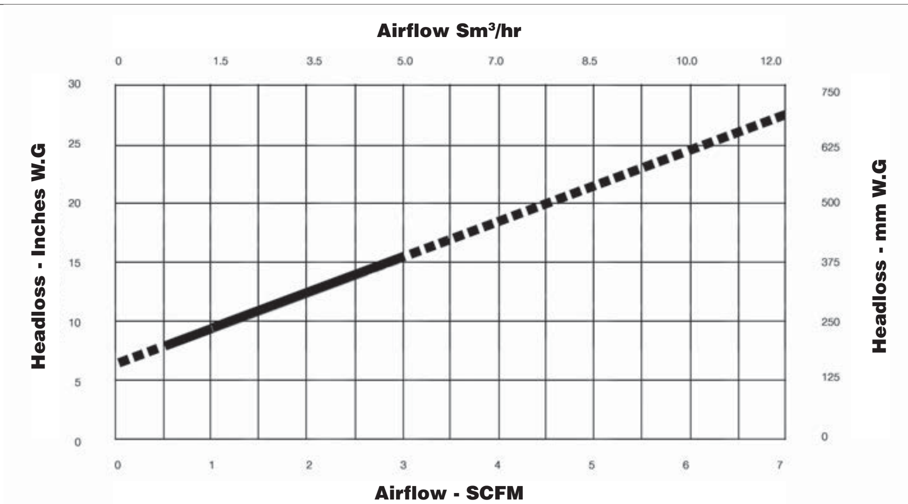
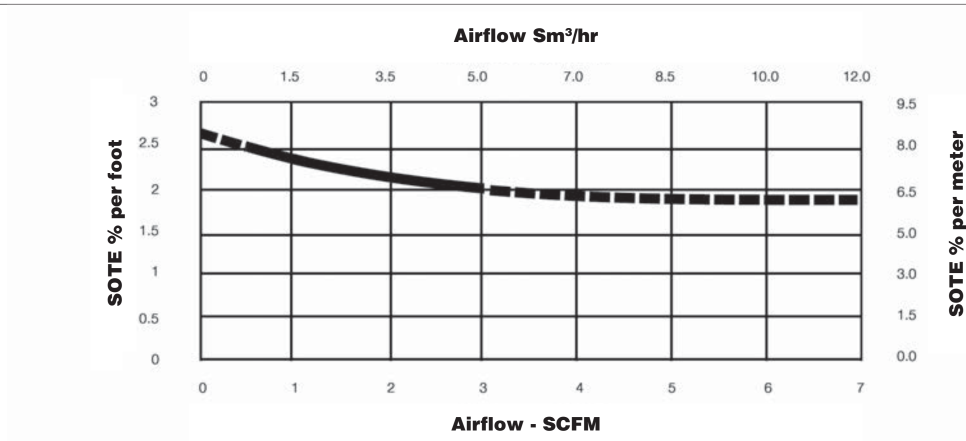
SSI™ FINE BUBBLE DIFFUSERS *continued*

AFD270 9" DISC







DESIGN FLOW	FLOW RANGE	ACTIVE SURFACE AREA	SLIT QUANTITY	WEIGHT
1.5 - 3.0 SCFM (2.5-5.0 Sm³/hr)	0-7 SCFM (0-12 Sm³/hr)	0.41 ft² (0.0375 m²)	6,600	1.5 lbs (680 g)

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SSI™ ADVANCED MEMBRANE MATERIALS

EPDM

Manufactured by compression molding with a standard cure, low plasticizer content, and 1mm or 2mm perforations. Compression molding with modern equipment utilizing individual thermocouples and vacuum technology ensures a repeatable very high quality product.

COST SCALE									
★									

LOWEST — HIGHEST

fEPDM

fEPDM membranes were developed in 2007 as an answer to those few cases where solvents were present and posed a risk to PTFE-coated membranes, and patent protection was filed for in 2008. In practice, they have outstanding chemical resistance similar to Viton®. A significant additional benefit of fEPDM membranes is that the entire outer surface area of the membrane is protected. This proprietary process also treats and protects the inner slits!

COST SCALE									
		★							

LOWEST — HIGHEST

PTFE

Developed in 2004, and patent protection filed for in 2005, the PTFE-coated EPDM membrane is now proven technology. The PTFE surface layer protects the EPDM substrate from chemical attack, while at the same time significantly reducing surface fouling on the membrane. In time, we expect to learn that PTFE-coated EPDM membranes outlast standard EPDM, thereby reducing the life cycle costs even further. Industrially, this product is a "must have," and has become the industry standard in pulp and paper, dairy, refinery, carbonated beverage, and landfill leachate applications. Municipally, it is used by major cities worldwide due to the anticipated life cycle cost benefits and reduced maintenance.

COST SCALE									
		★							

LOWEST — HIGHEST

VITON®

This material has been used successfully by SSI in a few applications where cost is not an issue. The membrane works very well, and is highly resistant to most foulants and chemicals. However, it is quite costly. Viton® costs us about 10 times what we pay for EPDM.

COST SCALE									
									★

LOWEST — HIGHEST

Viton® is a registered trademark of DuPont.

PEROXIDE-CURED EPDM

In those cases where the highest possible temperature resistance is required, a peroxide cure enables our membrane to operate to 250° F (120° C).

COST SCALE									
	★								

LOWEST — HIGHEST

ULTRA FINE BUBBLE

SSI ultra fine bubble membranes produce bubbles of < 1mm in diameter as compared to 1-3mm in diameter for our other membranes. This membrane is perforated with needles as opposed to slits, and the headloss is slightly higher. However our unique approach to ultra fine bubble membranes results in a lower headloss than competitors' products. SSI ultra fine bubble membranes are thin, structurally reinforced, and have a special coating specifically designed by SSI chemists to provide the most hydrophobic surface possible. With SSI ultra fine bubble membranes, no daily relaxing is required, and moisture is purged from the system in the usual way, as all of our systems are installed on a piping grid.

COST SCALE									
			★						

LOWEST — HIGHEST

Please see reverse for additional technical data

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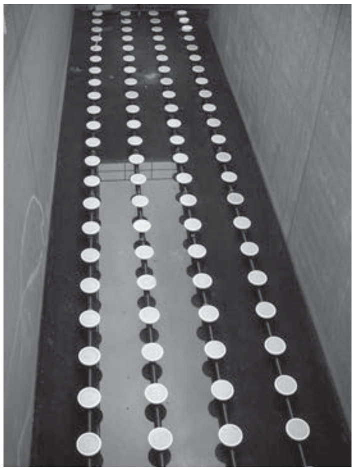
T E C H N I C A L   D A T A   S H E E T

SSI™ ADVANCED MEMBRANE MATERIALS

continued



R E F E R E N C E S

MENASHA, WISCONSIN – 2005
SCA Tissue North America LLC
Fine Bubble Diffuser System (750 pieces of AFD350-P: 12" Disc Diffusers with PTFE coating)

ALMA, KANSAS – 2006
Alma WWTP
Fine Bubble Aeration (160 pieces of AFD350-P: 12" Disc Diffusers with PTFE coating)

MEXICO CITY, MEXICO – 2004, updated 2006
Danone de Mexico WWTP
Fine Bubble Aeration System (800 pieces of AFD350 – 12" Disc Diffusers)

EAGLE, ID – 2007
Avimore Water Reclamation Facility
Three (3) Aeration basins with Fine Bubble Aeration (243 total pieces of AFD270-P: 9" Disc Diffusers with PTFE-coated membranes)

SINCLAIR, WY – 2006
Sinclair Wyoming Refining Company
Fine Bubble Aeration (1,120 feet of 80mm x 3048mm PTFE-coated tube membranes)

QUEBEC, CANADA – 2004
Agropur Cheese Plant
Fine Bubble Aeration (1,300 pieces of 9" PTFE-coated disc membranes)

OSWEGO, IL – 2008
Fox Metro Water Reclamation District
Fine Bubble (3,048 pieces of AFD350-P: 12" Disc Diffuser w/ PTFE-coated membrane)

LILLESTROM, NORWAY – 2007
Dynea Norway
Fine Bubble Aeration (832 pieces of 91 x 500mm diffusers w/ PTFE-coated membranes & 138 pieces of 91 x 1000mm diffusers w/ PTFE-coated membranes)

SAUDI ARABIA – 2005 thru 2008
North Jeddah & West Makka
Wastewater Treatment Plants
Fine Bubble Aeration (70,000 pieces of AFD270-P: 9" Disc Diffusers with PTFE-coated membranes)

OSWEGO, IL (PHASE II) – 2008
Fox Metro Water Reclamation District
Fine Bubble (3,048 pieces of AFD350-P: 12" Disc Diffuser w/ PTFE-coated membrane)

MATANE, QC – 2008
Tembec Pulp and Paper
Replacing Sanitaire™ 9" membrane discs
500/22,000 pieces shipped 2008 – pending results of pilot test, balance will ship

TROIS RIVIERES, QC – 2008
Kruger Wayagamack
9200 pieces 9" PTFE membrane replacing Sanitaire™ 9" membrane discs

UP, MICHIGAN
Versa Coated Paper
8000 pieces 9" PTFE membrane

WYOMING – 2007
Sinclair Oil Refinery
PTFE tube diffusers

CITY OF SEDALIA, MO – 2007
PTFE tube membrane replacement – replaced torn silicone diffusers

FRANCE – 2007
Yoplait Yogurts
Tube Diffusers

CITY OF SYDKYSTEN, DENMARK – 2007

CITY OF FREDERIKSHAVN, DENMARK – 2007

NIELSENS FISH EXPORT, DENMARK – 2006

FRANKLINTON, NC USA – 2006
Novozymes
PTFE tube diffusers

NORWAY – 2006
Dynea
PTFE tube diffusers

YORKSHIRE WATER, UK
Multiple Sites
All replacement work of existing EPDM diffusers - 20,000 pieces AFD270 PTFE – 2006-present. Each site SOTE tested; client fully satisfied with all purchases.

ARGENTINA
YPF/Repsol – Viton® membranes
Viton® is a registered trademark of DuPont.

PROJECTS SHOWN ABOVE:
Left: North Texas Municipal WWTP, USA
Center: Danone (Dairy) WWTP, Mexico
Right: Songnam Municipal WWTP, Korea

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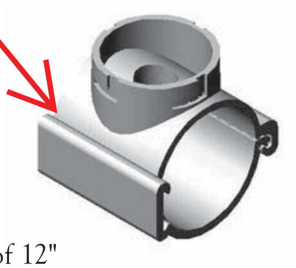
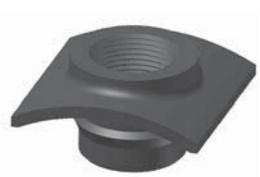
SSI™ ACCESSORIES

SADDLES



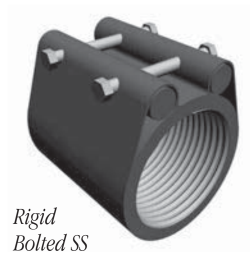
Patented Quick Connect Saddles mount on nominal US 4" or metric 110mm OD pipe. They allow retrofit of 12" to 9" discs without changing the piping system. Quick Connect Saddles are made of polypropylene, and install into a 1-1/2" (38mm) hole.

GROMMETS



Grommets are available for round plastic or square stainless steel pipes in US or Metric dimensions. Installation is simple. Multiple sizes are available based on pipe wall thickness. Grommets install into a 1-1/4" (32mm) chamfered hole.

EXPANSION JOINT OPTIONS



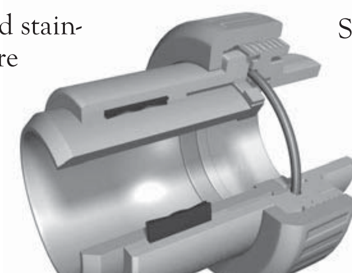
Rigid Bolted SS

Expansion Joints are available in three types: Flexible PVC with SS Shell, Rigid Bolted SS, and Anti-rotation, Telescoping PVC. The flexible expansion joints are recommended for disc installations and the positive locking type for tube diffuser projects.

Flexible PVC w/SS shell

Slotted band joints with stainless steel shear rings are suitable for disc-type fine bubble and cap-type coarse bubble lateral plastic piping systems, in conjunction with SSI's fixed and guide support stand system to manage thermal expansion and contraction.

Positive locking bolted stainless steel couplings are suitable for drop pipes, stainless joints, and for all tube diffuser piping systems to restrict header pipe rotation.

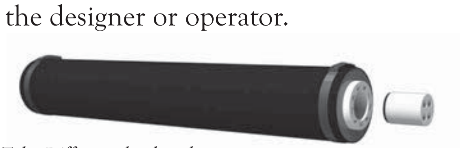


Anti-rotation, Telescoping PVC

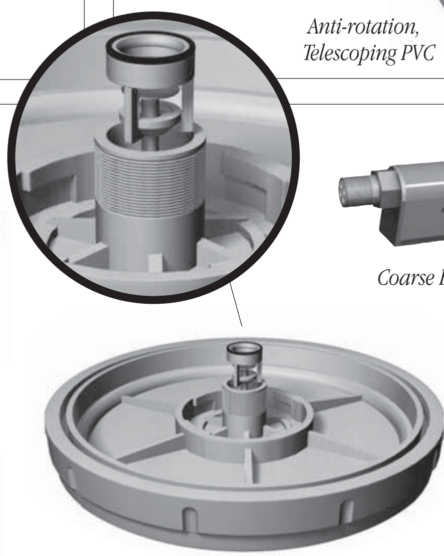
SSI's Sliding Expansion Joint is an anti-rotational telescopic union which absorbs pipe expansion and contraction to up to 1.5" (38mm).

CHECK VALVES

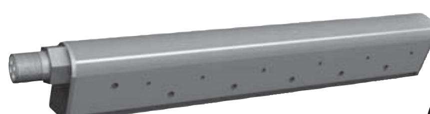
SSI fine and coarse bubble diffusers are available with optional check valves. These are not required for proper operation since most diffusers are self-checking, but they may give peace of mind to the designer or operator.



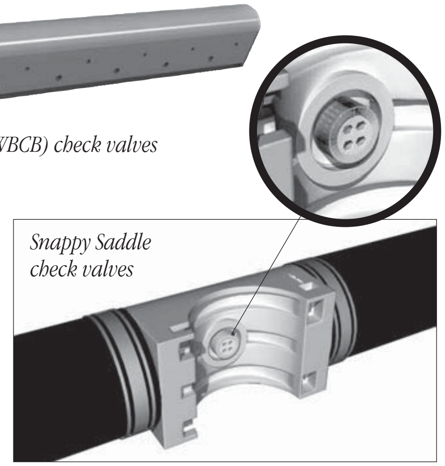
Tube Diffuser check valves



Disc showing check valve installation



Coarse Band (WBCB) check valves



Snappy Saddle check valves

Please see reverse for additional technical data

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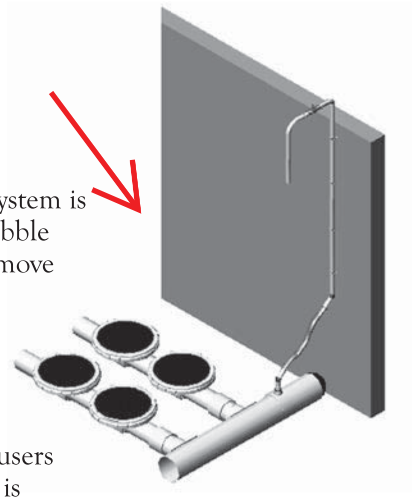
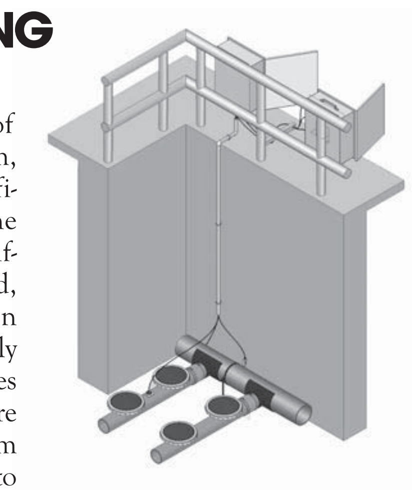
SSI™ ACCESSORIES *continued*

MOISTURE PURGE SYSTEM



An airlift type purge system is used in all SSI fine bubble aeration systems to remove condensate from the piping system. Purging entrained water helps ensure even air distribution to all diffusers in a grid. A ball valve is supplied with the system and is opened manually. Continuous purge systems are available for retrievable-type aeration systems, or where it is not possible to fasten a purge line to a tank wall.

PRESSURE MONITORING SYSTEM



Throughout the life of an aeration system, oxygen transfer efficiency may decline somewhat when diffusers become fouled, but headloss can increase dramatically which in turn increases energy costs. A pressure monitoring system enables the operator to better determine the optimal cleaning frequency of the membranes. The fouling rate can vary by aeration zone, hence it is recommended to install at least one system in each zone.

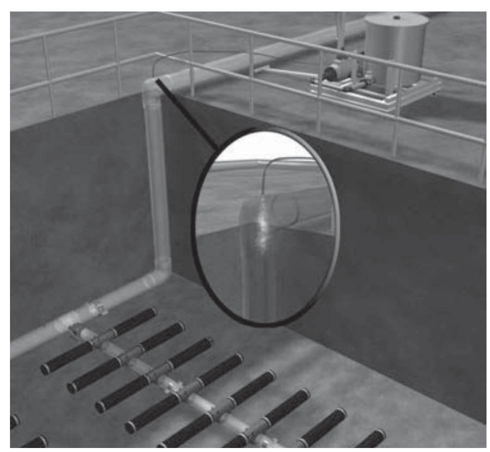
SUPPORT STANDS

Support Stands are available in 304 SS, 316 SS or in ABS plastic. SSI's standard is 304 SS with drop-in anchor bolts. In our aeration piping systems, support stands fulfill the dual role of anchoring pipes to the floor and controlling thermal expansion and contraction. Special support stands for uneven tank floors, for installing into concrete ballast forms, and for tanks with significant channel velocity (with lateral supports) are also available. ABS support stands are primarily used with disc diffusers and plastic pipe, where a low capital cost is the primary objective.

Above: ABS plastic support stand

ACID DOSING SYSTEM

In-situ Acid Dosing Systems are available to control calcareous deposits in the perforations which will reduce membrane backpressure.



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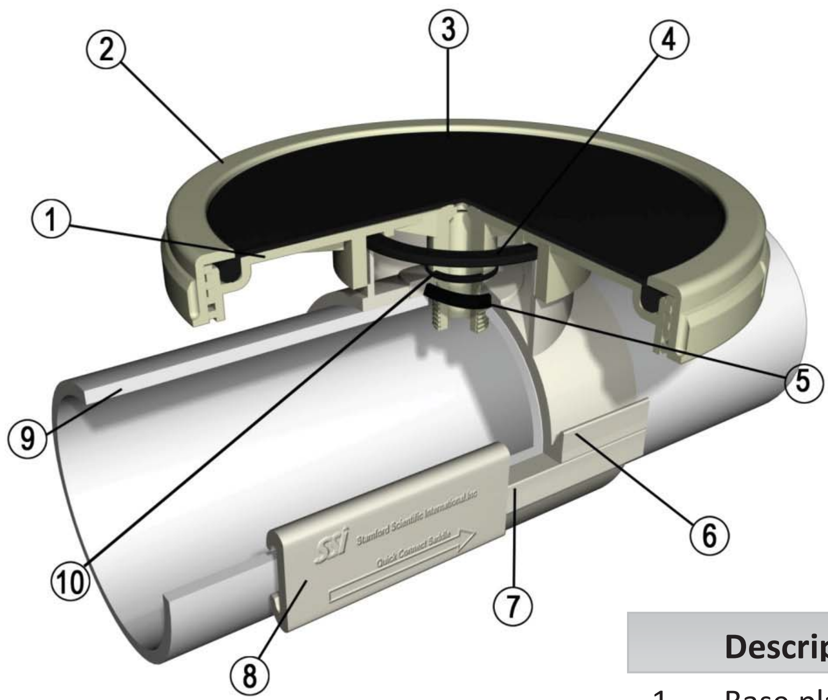
SSI™ DISC DIFFUSERS COMPONENTS WITH Ø4” QC SADDLE



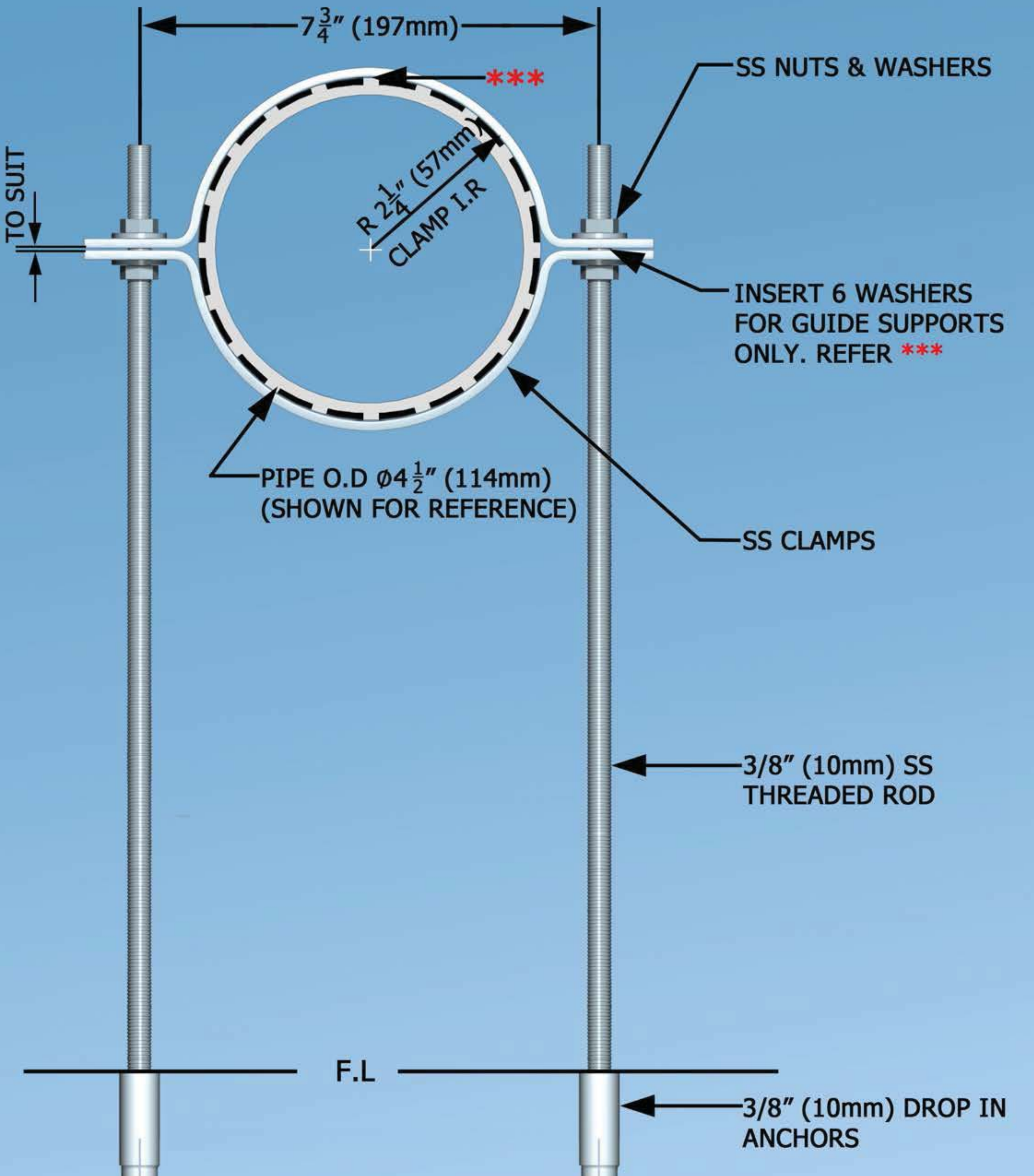
ASSEMBLED VIEW

	Description	Material
1	Base plate	PP (Polypropylene)
2	Retainer ring	PP (Polypropylene)
3	Membrane	EPDM / PTFE / fEPDM™ / Viton
4	Ø3⅜” Gasket	EPDM
5	Ø1¾” (I.D) x Ø2⅛” (O.D) 3D O-ring	EPDM
6	QC Upper saddle	PP (Polypropylene)
7	QC Lower saddle (QCS 4”)	PP
8	QC Wedge	PP (Polypropylene)
9	4½” Pipe (O.D)	
10	1” O-ring	EPDM

Model Details

	AFD270	AFD350
Pipe (O.D)	Ø4½”	Ø4½”
Retainer ring (O.D)	Ø10½”	Ø1’-1¾”
Membrane	Ø9”	Ø12”
Hole size on pipe	Ø1¾”	Ø1¾”
Design air flow range	1.5 to 3.0 SCFM	2.5 to 5.0 SCFM
Active surface area	0.41 ft²	0.70 ft²

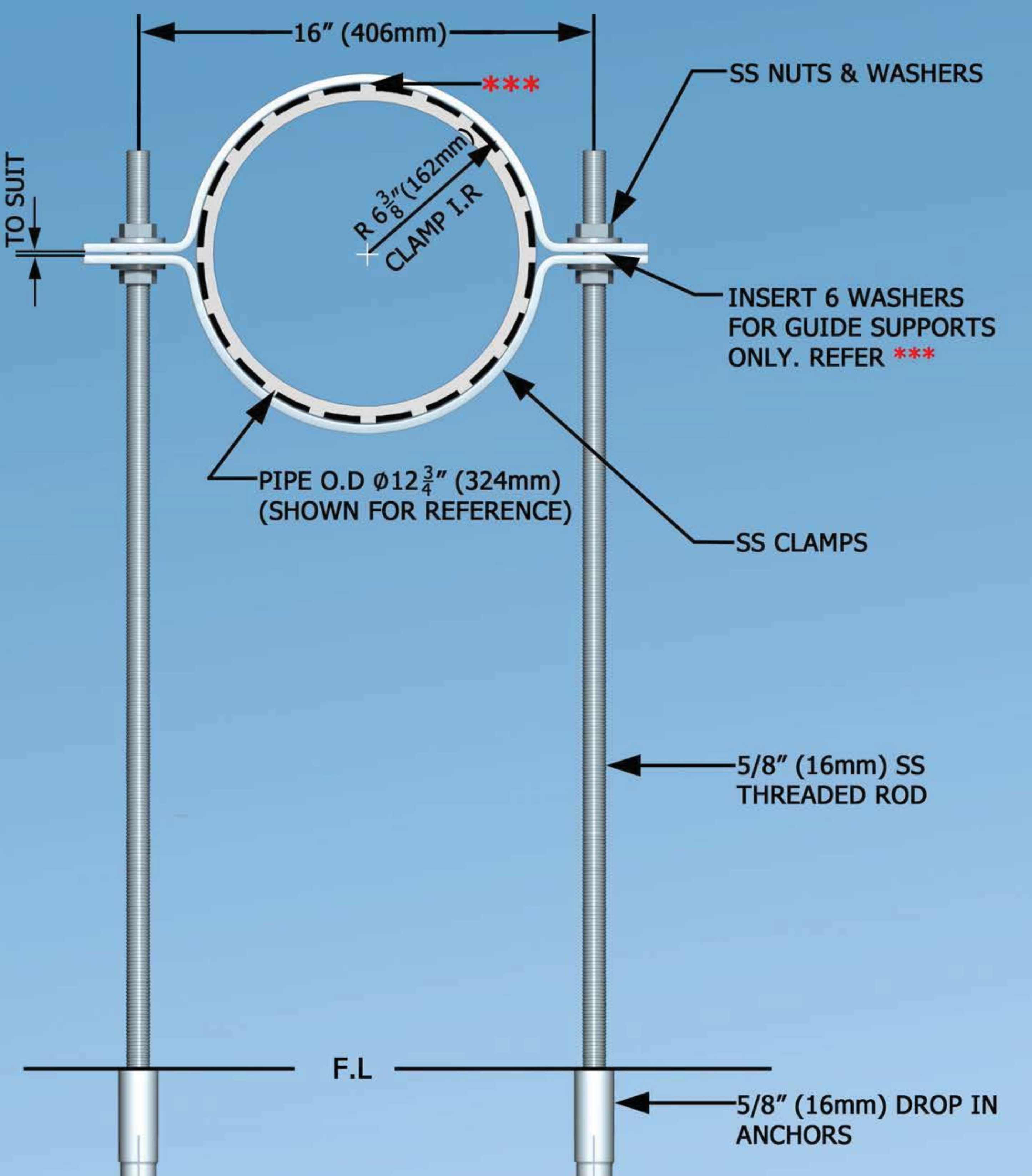
4" (110mm) NORMAL DUTY SUPPORT DETAILS



MATERIAL: 304SS OR 316SS (REFER SCOPE)

*** - FOR FIXED SUPPORT NO GAP PIPE O.D IS IN CONTACT WITH CLAMP I.D
FOR GUIDE SUPPORT ±1/16" (±1.5mm) GAP BETWEEN PIPE O.D AND I.D OF CLAMP

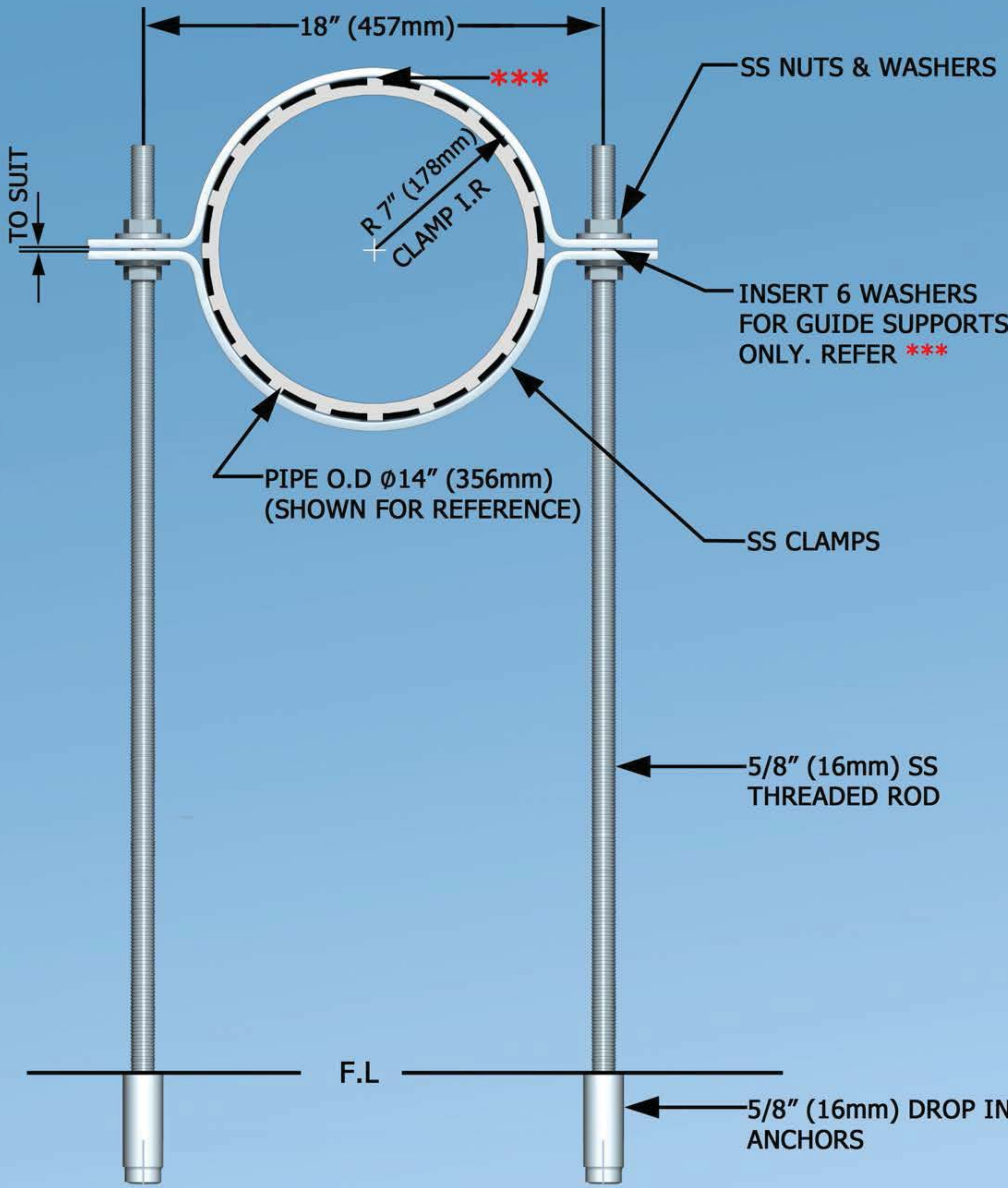
12” (325mm) NORMAL DUTY SUPPORT DETAILS



MATERIAL: 304SS OR 316SS (REFER SCOPE)

*** - FOR FIXED SUPPORT NO GAP PIPE O.D IS IN CONTACT WITH CLAMP I.D
FOR GUIDE SUPPORT ±1/16” (±1.5mm) GAP BETWEEN PIPE O.D AND I.D OF CLAMP

14" (350mm) NORMAL DUTY SUPPORT DETAILS



MATERIAL: 304SS OR 316SS (REFER SCOPE)

*** - FOR FIXED SUPPORT NO GAP PIPE O.D IS IN CONTACT WITH CLAMP I.D
FOR GUIDE SUPPORT ±1/16" (±1.5mm) GAP BETWEEN PIPE O.D AND I.D OF CLAMP

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Poughkeepsie, N.Y. 12603, U.S.A.

Tel: 845-454-8171 Fax: 845-454-8094
Email: tom@StamfordScientific.com
Site:www.StamfordScientific.com

Sample United States References

Dear Sir or Madam,

Thank you for considering SSI as a potential vendor! For over 15 years our mission has been to advance the aeration system markets through superior technology. SSI is a top industry leader when it comes to aeration products and has been granted patents for its technological contribution to the aeration community. The choice to select SSI as a vendor is one that links you with some of the most sophisticated, high-performance and high-efficiency solutions available in today's market for your system.

SSI's two founders initially built the business through their high-profile international contacts. Therefore many (but by no means all) of our largest and most prestigious installations are outside of the United States.

Attached to this document are customer testimonials of complete system installations within the United States.

Sincerely,
SSI

ARIZONA

1. **Phoenix, Arizona**

Project Name: **91st Ave WWTP**
System Type/Quantity: **11,200 pcs of AFD270 9" fluorinated EPDM membrane**
Installation Year: **2009**
Operator Contact:

Chuck Garvey
Chuck.garvey@pheonix.gov
Notes:
Later an additional 1,100 pcs of AFD270 9” fluorinated EPDM membranes were ordered

ARKANSAS

2. **North Little Rock, Arkansas**

Project Name: **North Little Rock Wastewater Utility**

System Type/Quantity**: Replacement project consisting of 4,570 pcs of 9” PTFE membrane and backer plate**
Installation Year**:2011**
Contact:
Lyle Leubner
lleubner@northlittlerock.ar.gov

CALIFORNIA

3. **Camarillo, CA**

Project Name: **City of Thousand Oaks, CA**
System Type/Quantity**: Replacement project. To date 3,700 pcs of 9” PTFE membrane and 600 pcs of AFD270-P, 9” discs with PTFE membrane have been installed**
Installation Year**:2011**
Owner/Operator Contact**:**
Chuck Rogers, Plant Superintendent
Tel. (805) 491-8177

4. **Novato, California**

Project Name: **Milbrae Water Pollution Control Plant Renovations**
System Type/Quantity:
Two aeration tanks, each consisting of two grids. Each tank has 693 pcs of AFD270 9” fine bubble disc diffusers with compression molded EPDM membranes and quick connect saddle connection. Total of 1.386 pcs for the project. (692*2= 1386)
Installation Date (Year): **2011**

CANADA

5. **Trois- Rivieres. QC**

Project Name: **Kruger Wayagamack**
System Type/Quantity:
Membranes only- 4,500pcs of 9" PTFE coated membrane
Installation Year: **2010**

Kruger Wayagamack,Inc
1 lle de la Potherie
C.P 128
Trois- Rivieres
QC, G9A5E9
Canada
Contact: Jacques Aubry- Mat Superi
Tel;819-373-9280

6. **Matane QC**

Project Name: **Tembec**
System Type/Quantity:
Membranes only- 500pcs of 9" PTFE coated membrane
Installation Year: **2008**
Tembec
Les Entreprises TembecInc
Groupe des Pates
Usine MATANE Operations
400, rue du Port
C.P 640
Matane, QC G4W3P6
Contact: Kent Murray
Tel;418-562-7272

7. **Granby, Quebec**

Project Name: **City of Granby**
System Type/Quantity: **2,200 pcs of 9" fEPDM membranes**
Installation Year: **2009**
Operator Contact: **Mr. Claude Ouimette**
Tel. **(450) 776-8371**

GEORGIA

8. **Jonesboro, Georgia**

Project name: **W.B. Casey-WRP**
System type/Quantity:
9" fEPDM membrane only (3,000 pcs of AFD270-P05-f)
Owner/Operator Contact:
Chris Hamilton-Plant Supervisor, Clayton County Water Authority
Tel: 770-478-7496
Fax: 770-478-7301

ILLINOIS

9. **Canton, Illinois**

Project Name: **Canton WWTP**
System Type/Quantity:
Aerobic Digester (150pc of AFD270 – 9" Fine Bubble Disc Diffusers)
Installation Year: **2006**
Operator Contact:
Joe Caruthers – Plant Superintendent
Tel: 309-647-1391
Engineer Contact:
Keith Plavec (City Engineer)
Tel: 309-647-7831

10. Marseilles WWTP

Project Name: **City of Marseilles WWTP**
System Type/Quantity: **Two (2) Aerobic Digesters, Fine Bubble (490 pcs AFD270, 9" disc diffusers with EPDM membranes)**
Installation Year: **2008**
Owner Contact:
City of Marseilles
2 SpicerLane
Marseilles, IL 61341
Supt: Don Christensen
Tel: 815.795.2150.
Email: marswwtf@mtco.com
Contractor Contact:
JJ Henderson & Son
4288 Old Grand Ave
Gurnee, IL 60031
Bart Rhodes
Tel: 847.244.3222

11. Joliet, Illinois

Project Name: **Joliet WWTP**
System Type/Quantity:
Aeration System with 12 tanks and a total of 16,704 pcs of AFD270-P
Installation Year: **2011-2012**

INDIANA

12. Eagle, Indiana

Project Name: **Avimore Water Reclamation Facility**
System Type/Quantity:
Three (3) Aeration basins with Fine Bubble Aeration (243 total pcs of AFD270-P: 9" Disc Diffusers with PTFE-coated membranes)
One (1) Sludge Holding Tank with Coarse Bubble Aeration (41pcs of 24" SS Wideband Diffusers)
Installation Year: **2007**
Owner Contact:
SunCor Development Co.
Tempe, AZ 85281
480-317-6800

IOWA

13. **Denison, Iowa (2)**

Project Name: **Denison Municipal Utilities WWTP**
System Type/Quantity:
Fine Bubble (1,975 pieces of AFD270 - 9” Disc Diffusers)
Installation Year: **2003 (Updated 2005)**
Operator Contact:
Todd Allen
Tel: 712-263-5116
Engineer Contact:
HDR
Steven Hergert
Tel: 402-391-0496
Notes: **Update of project at Denison in 2005: consisted of replacing 1,975 Aercor Ceramic Diffusers with SSI 9” EPDM membrane disc diffusers, and SSI was sole sourced for this project.**

KANSAS

14. **Dodge City, Kansas**

Project Name: **Cargill Meat Solutions Corporation**
System Type/Quantity:
Aeration System for 4 SBR basins with a total of 17.896 pcs of AFD270-P with QCS
Installation Year: **2011-2012**
Owner/Engineer Contact:
Kim Grieb
Tel: 620-338-4485

KENTUCKY

15. **Elizabethtown, Kentucky**

Project Name: **Elizabethtown Kentucky WWTP**
System Type/Quantity: **One fine bubble Aeration System consisting of two post aeration tanks: total of 296 pcs of AFD270 9” fine bubble dic diffusers with compression molded EPDM membranes and SSI patent Quick Connect Saddle Connection**

LOUISIANA

16. **Meraux, LA**

Project Name: Munster WWTP
System Type/Quantity: 4,758 pcs of AFD270, 9” disc diffuser with EPDM membrane and 148 pcs of 304SS WBCB diffuser
Installation Year: 2011

Contact:
Tim Stewart
985-624-8569

MARYLAND

17. Piscataway MD WWTP

Project Name: **Piscataway WWTP**
System Type/Quantity:
Replacement Project including 4,395 pcs of 9” PTFE membrane only, 855 pcs of AFD270, and 1,350 pcs of 9” EPDM membrane only
Installation Year: **2010-2011**
Owner Contact:
Randy Clark

MASSACHUSETTS

18. Lee, Massachusetts

Project Name: **Lee WWTP**
System Type/Quantity:
Fine Bubble Aeration (3,120 pieces of AFD270 – 9” Disc Diffusers with EPDM membranes)
Installation Year: **2006**
Owner Contact:
Town of Lee Dept of Public Works
Chris Pompi
Tel: 413-243-5520
Operator Contact:
Michael Towler– Chief Operator
Tel: 413-243-5526
Engineer Contact:
Metcalf & Eddy/AECOM
Tel: 781-246-5200
Notes: **(4) units ofSequencing Batch Reactors (SBR’s)**

MICHIGAN

19. Port Huron, Michigan

Project Name: Port Huron WWTP
System Type/Quantity: **Three aeration tanks with a total of 2,328 pcs of AFD270 9” Fine bubble disc diffusers with compression molded EPDM membrane**
Installation Year: **Project completed on 3-23-2010**
Project Engineer:
Ken Kingsley
Tetra Tech
Tel. 810-499-2320

MONTANA

20. **ConocoPhillips Company (Petrochemical Application)**
Billings REFINERY
Billings, MT 59101
Date: July 2010

350 pcs of 9” PTFE membranes (membranes only) were supplied to start, to replace failed Sanitaire™ membranes after a year of operation in a tank. More replacements are expected.
Contacts: Dave Wittorf
Tel: 406-255-2663

Tom Landry, Maintenance Planner
Tel: 406-255-3300

NEW MEXICO

21. **Casa Blanca, New Mexico**

Project Name: **Dancing Eagle Casino**
System Type/Quantity:
Fine Bubble (330 pieces of AFD270 – 9” Disc Diffusers with EPDM membranes)
Installation Year: **2004**
Owner Contact:
Dancing Eagle Casino
I-40 Exit 108
Casa Blanca, NM
Tel: 505-552-7777

NEW YORK

22. **Carthage, New York**

Project Name: **Village of Carthage NY WWTP**
System Type/Quantity: **Replacement project consisting of 1,000 pcs of 9” PTFE membrane**
Installation Year: **2010**
Contact: **John English**
Tel. 315-493-1421

23. **Poughkeepsie, New York**

Project Name: **City of Poughkeepsie WWTP**
System Type/Quantity:
Fine Bubble Diffuser System (4,700 pieces of AFD270 – 9” Disc Diffusers)
Installation Year: **2003**
Operator Contact:

Ed Steeprock
Tel: 845-471-8165
Engineer Contact:
ATS Chester – Pittsburgh, PA
Contact: Bob Laskey/Chuck Brentz
Tel: 412-809-6600
Notes:
Awarded by CDM Constructors (Syracuse, NY)
West Jones, P.E.
Tel: 315-473-1145
Jeff Mullen
Tel: 315-374-1923

24. Newark, New York

Project Name: **Newark WWTP Aeration System &Biosolids Processing**
System Type/Quantity:
Fine Bubble Aeration (550 pc of 9" PTFE-coated Membranes w/ 2MM SLITS)
Installation Date (Year): **2007**
Operator Contact Info:
Notes: **Replaced 550pc of Aercor Diffusers**

25. Lagrange, New York

Project Name: **Titusville WWTP**
System Type/Quantity: **Aeration system for 2 SBR tanks with 600 pcs AFD270-P & QCS**
Installation Year: **2010**

New Mexico

26. Clovis, New Mexio

Project Name: **Clovis WWTP**
System Type/Quantity: **Two bio reactor basins including 6,848 pcs of AFD270 and 2 aerobic digesters with 360 pcs of Relia-bill diffuser**

27. Tar Heel, North Carolina

Project Name: **Smithfield Foods**
System Type/Quantity: **One aeration tank with 10 Grids: total of 6,080 pcs of AFD270 fine bubble disc with compression molded EPDM membranes**
Installation Date (Year): **August 2009**
Engineer Contact:
Jose Labrador
HDR, Inc,
402-399-1005
Operator Contact Info:
Randy Clark
Smithfield Packing
910-862-7675 ext. 384

OHIO

28. Xenia, Ohio

Project Name: **Xenia Ford Road WWTP Update**
System Type/Quantity:
Fine Bubble Aeration System (**1,000 pieces of AFD270 – 9” Disc Diffusers)**
Installation Year: **1997**
Operator Contact:
Jason Tincu/Dan Leavitt (Plant Operators)
Tel: 937-376-7271
Fax: 937-673-7563
Notes: **Upgraded in 2006 with an additional 600 pieces of AFD270**
Added additional 146 pcs AFD350, 12” disc diffusers with EPDM in 2009

29. South Bloomfield, Ohio

Project Name: **South Bloomfield WWTP**
System Type/Quantity:
Fine Bubble Aeration (600 pieces of AFD270 – 9” Disc Diffusers in two Aeration Tanks; 54 pieces of AFD270 in one Post-Aeration Tank)
Installation Year: **2005**
Owner Contact:
Village of South Bloomfield
Pickaway County, OH
Tel: 740-983-2541
Operator Contact:
WilfordGartian
Tel: 740-207-5762
Engineer Contact:
BBS Corporation
Tel: 614-888-3100

30. Pleasantville, Ohio

Project Name: **Walnut Creek, WWTP**
System Type/Quantity: **One post Aeration tank with two grids. Each grid contains 7pcs of AFD270 fine bubble disc diffusers with compression molded EPDM membrane and ¾” Nipple connection.Total number of diffusers for project is 14pcs of AFD270 (7*2=14)**
Installation Year: **As of 4/1/2010 Submittals for project have been sent, however they are awaiting approval**

OKLAHOMA

31. Pryor, OK

Project Name: **Orchids Paper Products OK Mill**
System Type/Quantity: **Fixed grid aeration system with 1,016 pcs of AFD270-P, 9” disc diffuser with PTFE membrane**
Installation Year: **2010**
Contact:
Roger Tibbets
ph. 918-824-4602

PENNSLYVANIA

32. Greenlane, PA

Project Name: Green Lane Malborough WWTP
System Type/Quantity: **Aeration system consisting of 252 pcs of AFD270-P, 9" disc diffuser with PTFE membrane and 10 pcs of PTFE coated Relia-bill diffuser**
Installation Year: **2010**

TEXAS

33. Round Rock, Texas

Project Name: **Cottonwood**
System Type/Quantity:
Fine Bubble Aeration for Disinfection Basin (16 pcs of AFD270 – 9" Disc Diffusers)
Installation Year: **2004**
Owner Contact:
Enviroquip, Inc.
Austin, TX 78766
Contact: George Urban
Tel: 512-834-6004
Operator Contact:
Randy Manning
Tel: 512-388-9696

34. Camp Swift, Texas

Project Name: **Camp Swift**
System Type/Quantity:
Fine Bubble Aeration (156 pcs of AFD270 – 9" Disc Diffusers)
Installation Year: **2006**
Owner/Engineer Contact:
Enviroquip, Inc.
Round Rock, TX 78681
Contact: Nathan Emsick
Tel: 512-834-6004
Operator Contact:
Randy Manning
Tel: 512-388-9696

35. Wylie, Texas

Project Name: **Wilson Creek WWTP / North Texas Municipal Water District**
System Type/Quantity: **Fine Bubble Aeration (33,5000 pcs AFD270-P05-P, 9" PTFE membrane and backer plates)**
Plant Rated Capacity: **75 MGD Max**
Installation Year: **2008, added additional membranes in 2009**
Plant Supervisor:

Jim Rutledge
3020 Orr Rd
Allen, TX
Tel: 972-562-0680
jrutledge@ntmwd.com
Engineer Contact:
Bruce Cole
P.O Box 2408, 505 E. Brown Street
Wylie, TX 75098
Tel: 972-562-0680
Director of Operation:
Ken Wesson
Tel: 972-442-5405
Chief Plant Operator:
Mr. Roger Farmer
Chief Plant Operator
NTMWD-Wilson Creek WWTP
O (972) 562-0680
c (214) 356-4664

Notes: Customer ordered 2,000 pcs of AFD270-P as a trial MBR, and then ordered 33,500 pcs AFD270-P to replace existing Sanitaire Ceramic diffusers.

36. Arlington, TX

Project Name: **Ft. Worth Village Creek WWTP**
System Type/Quantity:
11 Aeration Tanks including a total of 65,882 pcs of AFD270-P, 9" disc diffuser with PTFE membrane
Installation Year: **2010-2012**
Contact: **Velton Ellis**
817-243-4579
Contractor- **Archer Western**

UTAH

37. Logan, Utah

Project Name: **Schreiber Foods**
System Type/Quantity:
Fine/Coarse Bubble Diffuser System (1,120 pcs. of AFD270 – 9" Disc Diffusers)
Installation Year: **2004**
Operator Contact:
Tel: 435-752-8175
Fax:435-752-5257
Engineer Contact:
Pharmer& Associated
Bob Pharmer
671 E. RiverparkLane
Suite 140
Boise, ID 83706
Tel: 208-433-1900

VIRGINIA

38. **Winschell, Virginia**

Project Name: **Winchell WWTP**
System Type/Quantity:
Membranes only 600 pcs of AFD270 9" PTFE coated membranes
Installation Year: **late 2009**
Plant Operator:
Tim Fristoe
Town of Front Royal WWTP
Manassas Ave.
Extended Front Royal, VA 22630
540-653-3733
Notes:
Project was to replace existing Sanitaire diffusers that were having difficulty due to fouling and calcification.

WASHINGTON

39. **Tacoma, WA**

Project Name: **Pierce County Utilities**
System Type/Quantity: **Membranes only- 9,000 pcs of 9" PTFE coated membrane with 1x1 slits**
Plant Capacity: **28.7 MGD Average, 53 MGD peak flow**
Contact:
Howard Wellman
hwellma@co.pierce.wa.us

WISCONSIN

40. **Park Falls, WI**

Project Name: **Flambeau River Papers**
System Type/Quantity:
8,600pcs - 9" Fine Bubble disc diffusers with PTFE compression molded membrane
Installation Year: **2010**
Owner Contact:
Flambeau River Papers Corp.
200 North 1st Avenue
Park Falls, WI 54552
Contact: Bill Granzin
Tel: 715-762-5302

Sample OEM Customers

Enviroquip - Kubota (Membrane Bio-Reactors)
Eco Process div. Premier Tech (SBR's)
Philadelphia Mixer (HALO Oxidation Ditches)
Dynatec (Membrane Bio-Reactors)
Aeromix Systems (General)

Seghers(Unit-Tank BNR)

Sample Prestigious International References

Bangkok BMA3WWTP	15,000 pcs 9” disc, 1996
Bangkok BMA4WWTP	25,000 pcs 9” disc, 2002
Kwangju, Korea WWTP	68,000 pcs 9” disc, 1998
Iraq Reconstruction	12,000 pcs 91 x 1000 tube, 2003
Shanghai WWTP	17,000 pcs 9” disc, 1999
Makkah 1 South WWTP	42,000 pcs 9” disc, 2005
Caesbe, Brazil WWTP	6,600 pcs 9” disc, 2003
AylesburyWWTP	
Thames Water UK	3,300 pcs 9” disc, 2004
Maturin WWTP, Venezuela	
USAID2,400 pcs 91 x 1000 tube diffuser, 2003	
Makkah 2 North WWTP	24,752 pcs of 9” disc, 2006
West Jeddah WWTP	46,248 pcs of 9” discs, 2006

Sample Industrial Customers

Ferrari – Modena plant, Italy
Prado – America’s Cup Boat Testing Facility, Italy
Pepsi-Cola – China
Coca-Cola – Philippines, Vietnam, Malaysia
Brahma Brewery – Brazil
San Miguel Brewery – Indonesia
Entenmann’s Bakery – New Jersey
Excel Beef – Texas
Christ Tanneries - Uruguay
General Motors – Multiple locations US & Canada
Mitsukoshi Dep’t Store – The Ginza, Tokyo, Japan
Nestle Foods – Philippines
Kimberly Clark – Philippines
Procter & Gamble – Mexico, Belgium
Kraft Foods – USA, Philippines
Wako Chemical – West Virginia
Placia do Parana –Brazil
Tafisa do Brasil – Brazil
Sonoco do Brasil – Brazil
Scott Paper – Costa Rica

SSI Aeration, Inc.
4 Tucker Drive
Poughkeepsie, N.Y. 12603, U.S.A.

Tel: 845-454-8171   Fax: 845-454-8094
Email: tom@StamfordScientific.com
Site:www.StamfordScientific.com

Sample United States References

Dear Sir or Madam,

Thank you for considering SSI as a potential vendor! For over 15 years our mission has been to advance the aeration system markets through superior technology. SSI is a top industry leader when it comes to aeration products and has been granted patents for its technological contribution to the aeration community. The choice to select SSI as a vendor is one that links you with some of the most sophisticated, high-performance and high-efficiency solutions available in today's market for your system.

SSI's two founders initially built the business through their high-profile international contacts. Therefore many (but by no means all) of our largest and most prestigious installations are outside of the United States.

Attached to this document are customer testimonials of complete system installations within the United States.

Sincerely,
SSI

ARKANSAS

1. **North Little Rock, Arkansas**

   Project Name: **North Little Rock Wastewater Utility**

System Type/Quantity**: Replacement project consisting of 4,570 pcs of 9” PTFE membrane and backer plate**
Installation Year**:2011**
Contact:
Lyle Leubner
lleubner@northlittlerock.ar.gov

CALIFORNIA

2. **Camarillo, CA**

Project Name: **City of Thousand Oaks, CA**
System Type/Quantity**: Replacement project. To date 3,700 pcs of 9” PTFE membrane and 600 pcs of AFD270-P, 9” discs with PTFE membrane have been installed**
Installation Year**:2011**
Owner/Operator Contact**:**
Chuck Rogers, Plant Superintendent
Tel. (805) 491-8177

CANADA

3. **Trois- Rivieres. QC**

Project Name: **Kruger Wayagamack**
System Type/Quantity:
Membranes only- 4,500pcs of 9" PTFE coated membrane
Installation Year: **2010**
Kruger Wayagamack,Inc
1 lle de la Potherie
C.P 128
Trois- Rivieres
QC, G9A5E9
Canada
Contact: Jacques Aubry- Mat Superi
Tel;819-373-9280

4. **Matane QC**

Project Name: **Tembec**
System Type/Quantity:
Membranes only- 500pcs of 9" PTFE coated membrane
Installation Year: **2008**
Tembec
Les Entreprises TembecInc
Groupe des Pates
Usine MATANE Operations
400, rue du Port
C.P 640
Matane, QC G4W3P6
Contact: Kent Murray
Tel;418-562-7272

ILLINOIS

5. **Oswego, Illinois**

Project Name: **Fox Metro Water Reclamation District**
System Type/Quantity:
Fine Bubble (6,118pc of AFD350-P: 12" Disc Diffuser w/ PTFE-coated membrane)
Plant Rated Capacity: **125 MGD Peak**
Installation Year: **2008**
Owner Contact:
Fox Metro Water Reclamation District
682 B State Route 31
Oswego, IL 60543
Operator Contact Info:
None yet assigned.
Please contact Bob Bauer at Deuchler Associates, Inc. (Consulting Engineers)
Tel: 630-892-4378
Notes: **3,000 additional pcs of AFD350 with EPDM membrane were added in 2009.**

INDIANA

6. **Eagle, Indiana**

Project Name: **Avimore Water Reclamation Facility**
System Type/Quantity:
Three (3) Aeration basins with Fine Bubble Aeration (243 total pcs of AFD270-P: 9" Disc Diffusers with PTFE-coated membranes)
One (1) Sludge Holding Tank with Coarse Bubble Aeration (41pcs of 24" SS Wideband Diffusers)
Installation Year: **2007**
Owner Contact:
SunCor Development Co.
Tempe, AZ 85281
480-317-6800

7. **Tell City**

Project Name: **Tell City LTCP Water Treatment Plan**
System Type/Quantity: **Retrievable Fine bubble aeration system for one contact tank with 160 sets of AFTS3100-P (3" Snappy Saddle diffuser with PTFE membrane) and one stabilization tank with 136 sets of AFTS3100P**
Installation Year: **2010**
Contractor Contact:
Bowen Engineering
P.O Bo 40729
Indianapolis, IN 46240
Attn: Homer

Tel. 812-475-3880

KANSAS

8. **Alma, Kansas**

Project Name: **Alma WWTP**
System Type/Quantity:
Fine Bubble Aeration (160 pieces of AFD350-P: 12” Disc Diffusers with PTFE coating)
Installation Year: **2006**
Owner Contact:
City of Alma, KS
Tel: 785-556-8219
Operator Contact:
Max Kraus
Tel: 785-765-3502
Fax: 785-765-3648
Engineer Contact:
Mike Peterson
Ray Lindsey Company
Belton, MO
Tel: 913-339-6666
Note: **In the summer of 2010, and existing Aeration tank will be retrofitted with 68 pcs of AFD350 12” fine bubble disc diffusers with PTFE membranes. As of 4/26/2010 this project is still under construction.**

9. **Dodge City, Kansas**

Project Name: **Cargill Meat Solutions Corporation**
System Type/Quantity:
Aeration System for 4 SBR basins with a total of 17.896 pcs of AFD270-P with QCS
Installation Year: **2011-2012**
Owner/Engineer Contact:
Kim Grieb
Tel: 620-338-4485

MARYLAND

10. **Piscataway MD WWTP**

Project Name: **Piscataway WWTP**
System Type/Quantity:
Replacement Project including 4,395 pcs of 9” PTFE membrane only, 855 pcs of AFD270, and 1,350 pcs of 9” EPDM membrane only
Installation Year: **2010-2011**
Owner Contact:
Randy Clark

11. **Accokeek, MD**

Project Name: **Piscataway MD WWTP**
System Type/Quantity**: 2,000 pcs of AFD270-P, 9” disc diffuser with PTFE membrane**

MONTANA

12. Billings, MT

Project Name: **ConocoPhillips Company (Petrochemical Application)**
Billings REFINERY
Date: **July 2010**
System Type/Quantity**: 350 pcs of 9” PTFE membranes (membranes only) were supplied to start, to replace failed Sanitaire™ membranes after a year of operation in a tank. More replacements are expected.**
Contacts: **Dave Wittorf**
Tel: 406-255-2663
Tom Landry, Maintenance Planner
Tel: 406-255-3300

NEW YORK

13. Carthage, New York

Project Name: **Village of Carthage NY WWTP**
System Type/Quantity: **Replacement project consisting of 1,000 pcs of 9” PTFE membrane**
Installation Year: **2010**

14. Newark, New York

Project Name: **Newark WWTP Aeration System &Biosolids Processing**
System Type/Quantity:
Fine Bubble Aeration (550 pc of 9” PTFE-coated Membranes w/ 2MM SLITS)
Installation Date (Year): **2007**
Operator Contact Info:
Notes: **Replaced 550pc of Aercor Diffusers**

15. Lagrange, New York

Project Name: **Titusville WWTP**
System Type/Quantity: **Aeration system for 2 SBR tanks with 600 pcs AFD270-P & QCS**
Installation Year: **2010**

OKLAHOMA

16. **Pryor, OK**

Project Name: **Orchids Paper Products OK Mill**
System Type/Quantity: **Fixed grid aeration system with 1,016 pcs of AFD270-P, 9" disc diffuser with PTFE membrane**
Installation Year: **2010**

PENNSLYVANIA

17. **Greenlane, PA**

Project Name: Green Lane Malborough WWTP
System Type/Quantity: **Aeration system consisting of 252 pcs of AFD270-P, 9" disc diffuser with PTFE membrane and 10 pcs of PTFE coated Relia-bill diffuser**
Installation Year: **2010**

TENNESSEE

18. **Copperhill, TN**

Project Name: **Copperhill, TN WWTP**
System Type/Quantity: **Coarse bubble aeration system with 29 pcs of AFC75, PTFE coated 3" coarse bubble diffusers**
Installation Year: **2010**

TEXAS

19. **Wylie, Texas**

Project Name: **Wilson Creek WWTP / North Texas Municipal Water District**
System Type/Quantity: **Fine Bubble Aeration (33,5000 pcs AFD270-P05-P, 9" PTFE membrane and backer plates)**
Plant Rated Capacity: **75 MGD Max**
Installation Year: **2008, added additional membranes in 2009**
Plant Supervisor:
Mr. Roger Farmer
Chief Plant Operator
NTMWD-Wilson Creek WWTP
3020 Orr Road
Luca, TX 75002
O (972) 562-0680
c (214) 356-4664
Engineer Contact:
Bruce Cole
P.O Box 2408, 505 E. Brown Street
Wylie, TX 75098
Tel: 972-562-0680

Director of Operation:
Ken Wesson
Tel: 972-442-5405
Notes: Customer ordered 2,000 pcs of AFD270-P as a trial MBR, and then ordered 33,500 pcs AFD270-P to replace existing Sanitaire Ceramic diffusers.

20. Arlington, TX

Project Name: **Ft. Worth Village Creek WWTP**
System Type/Quantity:
11 Aeration Tanks including a total of 65,882 pcs of AFD270-P, 9" disc diffuser with PTFE membrane
6 Anoxic zones including a total of 504 pcs of 304SS WBCB diffusers
Installation Year: **2010-2011**
Owner Contact: **Currently in production expected for completion early 2012**

UTAH

21. Logan, Utah

Project Name: **Schreiber Foods**
System Type/Quantity:
Fine/Coarse Bubble Diffuser System (1,120 pcs. of AFD270 – 9" Disc Diffusers)
Installation Year: **2004**
Operator Contact:
Tel: 435-752-8175
Fax:435-752-5257
Engineer Contact:
Pharmer& Associated
Bob Pharmer
671 E. RiverparkLane
Suite 140
Boise, ID 83706
Tel: 208-433-1900

Update: **in 2010 Schreiber purchased an additional 1,120 pcs of AFD270-P, 9" discs with PTFE membrane**

VIRGINIA

22. Winschell, Virginia

Project Name: **Winchell WWTP**
System Type/Quantity:
Membranes only 600 pcs of AFD270 9" PTFE coated membranes
Installation Year: **late 2009**
Plant Operator:
Tim Fristoe
Town of Front Royal WWTP

Manassas Ave.
Extended Front Royal, VA 22630
540-653-3733
Notes:
Project was to replace existing Sanitaire diffusers that were having difficulty due to fouling and calcification.

WASHINGTON

23. Tacoma, WA

Project Name: **Pierce County Utilities**
System Type/Quantity: **Membranes only- 9,000 pcs of 9" PTFE coated membrane with 1x1 slits**
Plant Capacity: **28.7 MGD Average, 53 MGD peak flow**
Contact:
Howard Wellman
hwellma@co.pierce.wa.us

24. Port Townsend, WA
Project Name: **Port Townsend Paper Corporation**
System Type/Quantity: **Membranes only- 773- pcs 3.58 In x 39 IN long EPDM/PTFE compression molded membranes**
Installation Year: **2009**
Owner Contact:
Port Townsend Paper Corporation
100 Mill Road
Port Townsend, WA 98368
Yvonne Starkey
Tel: 360-379-2074
Engineer Contact:
Correct Equipment
Redmond, WA 98052
Contact: Bob Thurston
Tel:425-869-1233

WISCONSIN

25. Park Falls, WI

Project Name: **Flambeau River Papers**
System Type/Quantity:
8,600pcs - 9" Fine Bubble disc diffusers with PTFE compression molded membrane
Installation Year: **2010**
Owner Contact:
Flambeau River Papers Corp.
200 North 1st Avenue
Park Falls, WI 54552

Contact: Bill Granzin
Tel: 715-762-5302

26. Menasha, Wisconsin

Project Name: **SCA Tissue North America LLC**
System Type/Quantity:
Fine Bubble Diffuser System (750 pcs. of AFD350-P: 12" Disc Diffusers with PTFE coating)
Installation Year: **2005**
Operator Contact:
SCA Tissue
Paul Johnson (Environmental Manager)
Tel: 920-725-7030
E-mail: Paul.l.Johnson@sca.com
Notes:
A) **Expansion of facilities led SCA Tissue to purchase an additional 450 pieces of AFD350-P diffusers from SSI in June of 2006.**
B) **Further expansion of facilities led to a purchase of 325 additional pieces of AFD350-P in September of 2006.**

WYOMING

27. Sinclair, Wyoming

Project Name: **Sinclair Wyoming Refining Company**
System Type/Quantity:
Fine Bubble Aeration (1,120 feet of 80mm x 3048mmPTFE-coated tube membranes)
Installation Year: **2006**
Owner Contact:
Sinclair Refining Company
100 Lincoln Highway
Sinclair, WY 82334
Operator Contact Info:
KlaneForsgren
Tel: 307-328-3587

Sample OEM Customers

Enviroquip - Kubota (Membrane Bio-Reactors)
Eco Process div. Premier Tech (SBR's)
Philadelphia Mixer (HALO Oxidation Ditches)
Dynatec (Membrane Bio-Reactors)
Aeromix Systems (General)
Seghers(Unit-Tank BNR)

Sample Prestigious International References

Bangkok BMA3WWTP	15,000 pcs 9” disc, 1996
Bangkok BMA4WWTP	25,000 pcs 9” disc, 2002
Kwangju, Korea WWTP	68,000 pcs 9” disc, 1998
Iraq Reconstruction	12,000 pcs 91 x 1000 tube, 2003
Shanghai WWTP	17,000 pcs 9” disc, 1999
Makkah 1 South WWTP	42,000 pcs 9” disc, 2005
Caesbe, Brazil WWTP	6,600 pcs 9” disc, 2003
AylesburyWWTP	
Thames Water UK	3,300 pcs 9” disc, 2004
Maturin WWTP, Venezuela	
USAID2,400 pcs 91 x 1000 tube diffuser, 2003	
Makkah 2 North WWTP	24,752 pcs of 9” disc, 2006
West Jeddah WWTP	46,248 pcs of 9” discs, 2006

Sample Industrial Customers

Ferrari – Modena plant, Italy
Prado – America’s Cup Boat Testing Facility, Italy
Pepsi-Cola – China
Coca-Cola – Philippines, Vietnam, Malaysia
Brahma Brewery – Brazil
San Miguel Brewery – Indonesia
Entenmann’s Bakery – New Jersey
Excel Beef – Texas
Christ Tanneries - Uruguay
General Motors – Multiple locations US & Canada
Mitsukoshi Dep’t Store – The Ginza, Tokyo, Japan
Nestle Foods – Philippines
Kimberly Clark – Philippines
Procter & Gamble – Mexico, Belgium
Kraft Foods – USA, Philippines
Wako Chemical – West Virginia
Placia do Parana –Brazil
Tafisa do Brasil – Brazil
Sonoco do Brasil – Brazil
Scott Paper – Costa Rica

TETRA TECH, INC.

ATTACHMENT C
SANITAIRE MEMBRANE DISC PROPOSAL
(OPTION 4)

SANITAIRE

a xylem brand

Diffused Aeration Equipment

for

City of Tampa WWTP

Fine Pore Aeration - Membrane Discs

Prepared For:

Tetra Tech RTW

1576 Sherman St.
Suite 100
Denver, CO 80203

Represented By:
Moss-Kelley Inc.
725 Primera Blvd - Suite 155
Lake Mary, FL 32746
407 805-0063

Sanitaire #s23698-13
February 12, 2013
im K:\s23698-13\2013.1.21 AB Set-Up (SS-II).aer

Sanitaire Aeration Design Inputs for: City of Tampa WWTP, Sanitaire #s23698-13

Tank Geometry

4 Trains each Consisting of:

Parameter	Units	Pass 1
Parallel Reactors		1
Pass Process		Aerobic
SWD	ft	17.0
Submergence	ft	15.9
Volume	ft³	286,518.6
Reactor Geometry:		Rect
Length	ft	318.0
Width	ft	53.0

Oxygen/Air Distribution

	Zone	1	2	3	4	5	6
	Pass	1	1	1	1	1	1
Default		32.0%	28.0%	20.0%	10.0%	6.0%	4.0%

Oxygenation

Parameter	Units	Current Avg. Day	Current Max Day	Future Avg. Day	Future Max Day
No. Trains Operating		4	4	4	4
Oxygen Requirement	lb/day	***50,000.0-A***	***90,000.0-A***	***70,000.0-A***	***126,000.0-A***

Standard Oxygen Correction Factor Parameters

Parameter	Units	Current Avg. Day	Current Max Day	Future Avg. Day	Future Max Day
Alpha		***0.55***	***0.55***	***0.55***	***0.55***
Beta		***0.95***	***0.95***	***0.95***	***0.95***
Theta		1.024	1.024	1.024	1.024
Dissolved Oxygen	mg/l	***2***	***1***	***2***	***1***
Site Elevation	FASL	7	7	7	7
Ambient Pressure	PSIA	14.70	14.70	14.70	14.70
Water Temperature	°C	***30***	***30***	***30***	***30***

Notes:

Bold, Italicized text indicate assumptions made by Sanitaire

A - Indicates Actual (AOR) Requirement.

S - Indicates Standard Condition (SOR) Oxygen requirement.

If the AOR/SOR parameter is not given, then its value will be evaluated later if suitable alpha, beta, D.O., theta, pressure, and temperature data is supplied.

Round tanks are evaluated as rectangular tanks diameter equal to length and equal surface area.

Annular tanks are evaluated as rectangular tanks of width equal to the annular width and equal surface area.

Sanitaire Project Name: City of Tampa WWTP
Sanitaire Project #s23698-13
Design Summary

		Point & O2			
	Units	Current Avg. Day Default	Current Max Day Default	Future Avg. Day Default	Future Max Day Default
No. Trains in Operation		4	4	4	4
No. Grids in Operation		24	24	24	24
No. Operating Diffusers		12,452	12,452	12,452	12,452
SOR	lb/day	127,303	187,874	169,992	258,975
SOTE	%	32.9	31.5	31.9	30.3
Total Air Rate	scfm	15,451	23,799	21,284	34,098
Min.Diffuser Air Rate	scfm/diff.	1.2	1.34	1.34	1.35
Max. Diffuser Air Rate	scfm/diff.	1.34	2.02	1.79	2.94
Static Pressure	psig	6.91	6.91	6.91	6.91
Diffuser DWP @ Min Air	psig	0.49	0.51	0.51	0.51
Diffuser DWP @ Max Air	psig	0.51	0.56	0.54	0.64
Pressure @ Top of Dropleg	psig	7.56	7.77	7.68	8.18
Est. Blower Efficiency		70%	70%	70%	70%
Est. Motor Efficiency		90%	90%	90%	90%
Shaft Power	Bhp	642.9	1,013	897.7	1,515
Est. Motor Electrical Load	kW	532.9	839.6	744.1	1,256
Est. Standard Aeration Efficiency	#SOR/BHP-hr	8.25	7.73	7.89	7.12

Notes:

(1) Design air is the maximum of process air or mixing air

(2) Delivered oxygen based on design air

(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss

(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.

(5) Diffuser Air Flow based on Active Valve Modulation

(6) Blower Pressure Capability also requires consideration of:

A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.

B. Potential for increased headloss resulting from diffuser fouling and/or aging. Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other

technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.

C. Increased diffuser submergence during Peak Flow conditions.

(7) Air Flow defined at 20°C

(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: City of Tampa WWTP
Sanitaire Project #s23698-13
Consulting Engineer: Tetra Tech RTW
Operating Condition: Current Avg. Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Pass		1	1	1	1	1	1	
SWD	ft	17.00	17.00	17.00	17.00	17.00	17.00	
Subm	ft	15.95	15.95	15.95	15.95	15.95	15.95	
Volume	ft^3	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	1,146,074.3
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		4	4	4	4	4	4	
Grid Count		1	1	1	1	1	1	24
Dropleg Diameter	inches	8	8	6	6	4	4	
At/Ad		7.51232	8.5640415	11.71151	21.959081	27.187433	27.187433	
Diffuser Density	% Floor	13.31%	11.68%	8.54%	4.55%	3.68%	3.68%	
Diffusers/Grid		912	800	585	312	252	252	12,452

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Diffuser Type		SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	
Alpha		0.55	0.55	0.55	0.55	0.55	0.55	
Beta		0.95	0.95	0.95	0.95	0.95	0.95	
Theta		1.024	1.024	1.024	1.024	1.024	1.024	
D.O.	mg/l	2	2	2	2	2	2	
Water Temp	°C	30	30	30	30	30	30	
AOR/SOR		0.4217	0.4217	0.4217	0.4217	0.4217	0.4217	0.4217
Oxygen Distribution	%/Zone	32.0%	28.0%	20.0%	10.0%	6.0%	4.0%	100.0%
AOR	lb/day	16,000.0	14,000.0	10,000.0	5,000.0	3,000.0	2,000.0	50,000.0
SOR	lb/day	37,945.1	33,201.9	23,715.7	11,857.8	7,114.7	4,743.1	118,578.3
Air Rate (7)	scfm							

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%							
Mixing Air (8)	scfm	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	
Process Air (for SOR)	scfm	4,476.8	3,936.4	2,848.7	1,492.0	883.1	554.8	
Design Air (1,7)	scfm	4,476.8	3,936.4	2,848.7	1,492.0	1,348.3	1,348.3	15,450.5
Diffuser Air Rate	scfm/Diff.	1.23	1.23	1.22	1.20	1.34	1.34	1.24
Delivered SOR	lb/day	37,945.1	33,201.9	23,715.7	11,857.8	10,291.4	10,291.4	127,303.3
Delivered SOTE	%	33.8%	33.7%	33.2%	31.7%	30.5%	30.5%	32.9%
Pressure @ Top of Dropleg	psig	7.50	7.49	7.51	7.47	7.56	7.56	7.56
Shaft Power	Bhp	185.1	162.6	117.9	61.5	56.1	56.1	642.9

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: City of Tampa WWTP
Sanitaire Project #s23698-13

Consulting Engineer: Tetra Tech RTW
Operating Condition: Current Max Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Pass		1	1	1	1	1	1	
SWD	ft	17.00	17.00	17.00	17.00	17.00	17.00	
Subm	ft	15.95	15.95	15.95	15.95	15.95	15.95	
Volume	ft^3	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	1,146,074.3
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		4	4	4	4	4	4	
Grid Count		1	1	1	1	1	1	24
Dropleg Diameter	inches	8	8	6	6	4	4	
At/Ad		7.51232	8.5640415	11.71151	21.959081	27.187433	27.187433	
Diffuser Density	% Floor	13.31%	11.68%	8.54%	4.55%	3.68%	3.68%	
Diffusers/Grid		912	800	585	312	252	252	12,452

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Diffuser Type		SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	
Alpha		0.55	0.55	0.55	0.55	0.55	0.55	
Beta		0.95	0.95	0.95	0.95	0.95	0.95	
Theta		1.024	1.024	1.024	1.024	1.024	1.024	
D.O.	mg/l	1	1	1	1	1	1	
Water Temp	°C	30	30	30	30	30	30	
AOR/SOR		0.4865	0.4865	0.4865	0.4865	0.4865	0.4865	0.4865
Oxygen Distribution	%/Zone	32.0%	28.0%	20.0%	10.0%	6.0%	4.0%	100.0%
AOR	lb/day	28,800.0	25,200.0	18,000.0	9,000.0	5,400.0	3,600.0	90,000.0
SOR	lb/day	59,194.2	51,794.9	36,996.4	18,498.2	11,098.9	7,399.3	184,981.9
Air Rate (7)	scfm							

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Mixing Criteria	$scfm/ft^2$	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%							
Mixing Air (8)	scfm	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	
Process Air (for SOR)	scfm	7,354.8	6,468.8	4,686.3	2,470.8	1,470.3	923.7	
Design Air (1,7)	scfm	7,354.8	6,468.8	4,686.3	2,470.8	1,470.3	1,348.3	23,799.3
Diffuser Air Rate	scfm/Diff.	2.02	2.02	2.00	1.98	1.46	1.34	1.91
Delivered SOR	lb/day	59,194.2	51,794.9	36,996.4	18,498.2	11,098.9	10,291.4	187,874.1
Delivered SOTE	%	32.1%	32.0%	31.5%	29.9%	30.1%	30.5%	31.5%
Pressure @ Top of Dropleg	psig	7.74	7.72	7.77	7.67	7.60	7.56	7.77
Shaft Power	Bhp	312.2	273.9	199.5	104.0	61.4	56.1	1,013.0

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 $scfm/ft^2$

Sanitaire Project Name: City of Tampa WWTP
Sanitaire Project #s23698-13

Consulting Engineer: Tetra Tech RTW
Operating Condition: Future Avg. Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Pass		1	1	1	1	1	1	
SWD	ft	17.00	17.00	17.00	17.00	17.00	17.00	
Subm	ft	15.95	15.95	15.95	15.95	15.95	15.95	
Volume	ft^3	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	1,146,074.3
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		4	4	4	4	4	4	
Grid Count		1	1	1	1	1	1	24
Dropleg Diameter	inches	8	8	6	6	4	4	
At/Ad		7.51232	8.5640415	11.71151	21.959081	27.187433	27.187433	
Diffuser Density	% Floor	13.31%	11.68%	8.54%	4.55%	3.68%	3.68%	
Diffusers/Grid		912	800	585	312	252	252	12,452

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Diffuser Type		SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	
Alpha		0.55	0.55	0.55	0.55	0.55	0.55	
Beta		0.95	0.95	0.95	0.95	0.95	0.95	
Theta		1.024	1.024	1.024	1.024	1.024	1.024	
D.O.	mg/l	2	2	2	2	2	2	
Water Temp	°C	30	30	30	30	30	30	
AOR/SOR		0.4217	0.4217	0.4217	0.4217	0.4217	0.4217	0.4217
Oxygen Distribution	%/Zone	32.0%	28.0%	20.0%	10.0%	6.0%	4.0%	100.0%
AOR	lb/day	22,400.0	19,600.0	14,000.0	7,000.0	4,200.0	2,800.0	70,000.0
SOR	lb/day	53,123.1	46,482.7	33,201.9	16,601.0	9,960.6	6,640.4	166,009.6
Air Rate (7)	scfm							

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Mixing Criteria	$scfm/ft^2$	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%							
Mixing Air (8)	scfm	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	
Process Air (for SOR)	scfm	6,517.9	5,732.3	4,151.7	2,185.3	1,298.8	815.9	
Design Air (1,7)	scfm	6,517.9	5,732.3	4,151.7	2,185.3	1,348.3	1,348.3	21,283.8
Diffuser Air Rate	scfm/Diff.	1.79	1.79	1.77	1.75	1.34	1.34	1.71
Delivered SOR	lb/day	53,123.1	46,482.7	33,201.9	16,601.0	10,291.4	10,291.4	169,991.5
Delivered SOTE	%	32.5%	32.4%	31.9%	30.3%	30.5%	30.5%	31.9%
Pressure @ Top of Dropleg	psig	7.66	7.65	7.68	7.60	7.56	7.56	7.68
Shaft Power	Bhp	274.4	240.8	175.1	91.4	56.1	56.1	897.7

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 $scfm/ft^2$

Sanitaire Project Name: City of Tampa WWTP
Sanitaire Project #s23698-13

Consulting Engineer: Tetra Tech RTW
Operating Condition: Future Max Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Pass		1	1	1	1	1	1	
SWD	ft	17.00	17.00	17.00	17.00	17.00	17.00	
Subm	ft	15.95	15.95	15.95	15.95	15.95	15.95	
Volume	ft³	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	1,146,074.3
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		4	4	4	4	4	4	
Grid Count		1	1	1	1	1	1	24
Dropleg Diameter	inches	8	8	6	6	4	4	
At/Ad		7.51232	8.5640415	11.71151	21.959081	27.187433	27.187433	
Diffuser Density	% Floor	13.31%	11.68%	8.54%	4.55%	3.68%	3.68%	
Diffusers/Grid		912	800	585	312	252	252	12,452

Oxygen Transfer

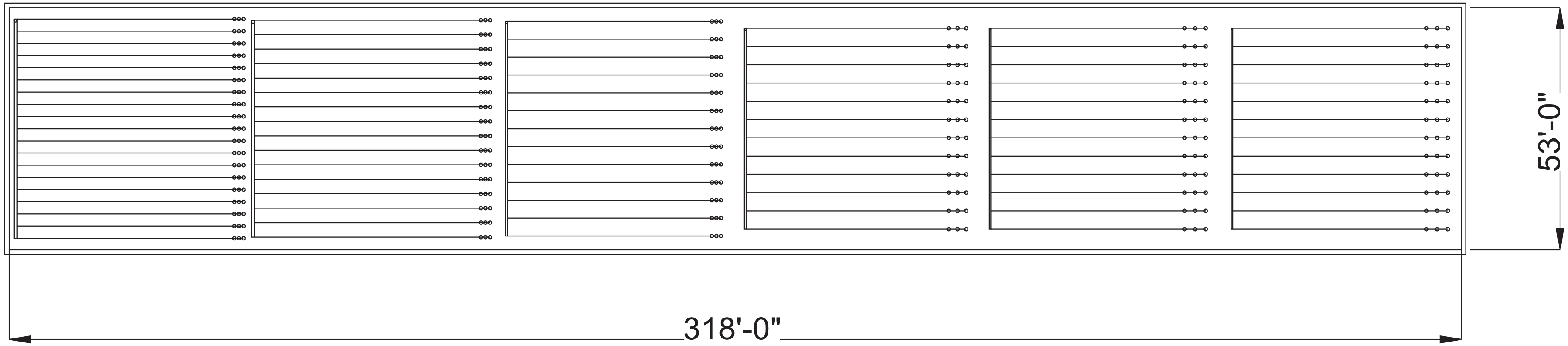
Diffuser Type		SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	SSII-9	
Alpha		0.55	0.55	0.55	0.55	0.55	0.55	
Beta		0.95	0.95	0.95	0.95	0.95	0.95	
Theta		1.024	1.024	1.024	1.024	1.024	1.024	
D.O.	mg/l	1	1	1	1	1	1	
Water Temp	°C	30	30	30	30	30	30	
AOR/SOR		0.4865	0.4865	0.4865	0.4865	0.4865	0.4865	0.4865
Oxygen Distribution	%/Zone	32.0%	28.0%	20.0%	10.0%	6.0%	4.0%	100.0%
AOR	lb/day	40,320.0	35,280.0	25,200.0	12,600.0	7,560.0	5,040.0	126,000.0
SOR	lb/day	82,871.9	72,512.9	51,794.9	25,897.5	15,538.5	10,359.0	258,974.7
Air Rate (7)	scfm							

Performance

Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%							
Mixing Air (8)	scfm	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	
Process Air (for SOR)	scfm	10,708.2	9,420.0	6,829.7	3,619.0	2,162.3	1,358.5	
Design Air (1,7)	scfm	10,708.2	9,420.0	6,829.7	3,619.0	2,162.3	1,358.5	34,097.6
Diffuser Air Rate	scfm/Diff.	2.94	2.94	2.92	2.90	2.15	1.35	2.74
Delivered SOR	lb/day	82,871.9	72,512.9	51,794.9	25,897.5	15,538.5	10,359.0	258,974.7
Delivered SOTE	%	30.9%	30.7%	30.3%	28.6%	28.7%	30.4%	30.3%
Pressure @ Top of Dropleg	psig	8.13	8.08	8.18	7.98	7.86	7.56	8.18
Shaft Power	Bhp	473.2	414.2	303.4	157.5	93.0	56.5	1,515.0

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²



Single Train Information

Grid No	Grid Count	Drop Leg Ø"	Header Count	Header Spc, ft.	Header Len, ft.	Discs/ Grid	At/ Ad	Discs/ Train
1	1	8	19	2.67	50.25	912	7.51	912
2	1	8	16	3.17	52.25	800	8.56	800
3	1	6	13	3.92	47.25	585	11.7	585
4	1	6	12	4.00	48.67	312	22.0	312
5	1	4	12	4.00	47.42	252	27.2	252
6	1	4	12	4.00	47.42	252	27.2	252

Total Discs/Train 3113

Note: Some headers may be omitted for clarity

PRELIMINARY – THIS DRAWING IS NOT INTENDED FOR CONTRACT DOCUMENTS, SUBMITTALS OR CONSTRUCTION

Sanitaire
a xylem brand
BROWN DEER, WISCONSIN 53223

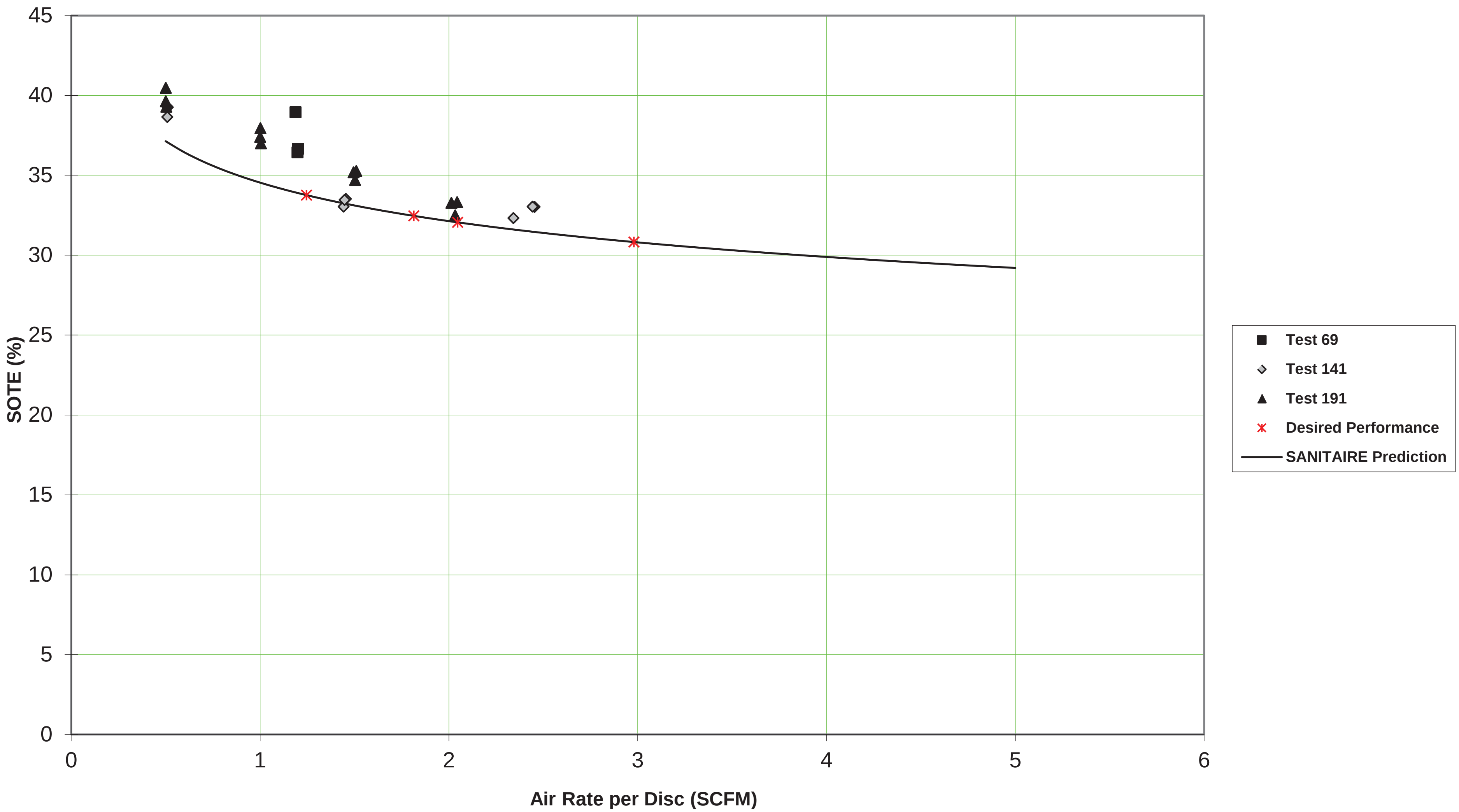
CUST NO.

DWG NO.

City of Tampa WWTP
9" Disc Aeration System

DRAWN BY IM | DATE 2/12/13
CHKD BY | DATE
APPVD BY | DATE
MODEL
JOB s23698-13
SHEET

SANITAIRE 9 inch Silver Series II Membrane Disc Diffusers
Experimental Data vs. Factory Performance Characteristic:
At/Ad=7.6, Data Normalized to 15.95 ft. Submergence and 1000 mg/l TDS



SANITAIRE CERTIFIED OTE TEST DATA

9 inch Silver Series II Membrane Disc (0.41 ft²/Disc)

TARGET: At/Ad = 7.61(+/- 7%). Submergence = 15.95 (ft.)(+/- 6%)., Water Depth = 17.00 (ft.)

TEST	RUN	Data Subm. (feet)	At/Ad	Data Air per Diff. (SCFM)	Data SOTE (%)	Subm. Corrected SOTE (%)
69	A1	15.700	7.850	**1.189**	38.33	**38.94**
69	A2	15.700	7.850	**1.202**	36.09	**36.66**
69	A3	15.700	7.850	**1.198**	35.87	**36.43**
141	B1	16.400	7.388	**1.443**	33.97	**33.03**
141	B2	16.400	7.388	**1.454**	34.47	**33.52**
141	B3	16.400	7.388	**1.449**	34.40	**33.45**
141	B4	16.400	7.388	**2.343**	33.24	**32.32**
141	B5	16.400	7.388	**2.454**	33.95	**33.02**
141	B6	16.400	7.388	**2.444**	33.97	**33.03**
141	B7	16.400	7.388	**0.509**	39.75	**38.65**
141	B8	16.400	7.388	**0.512**	40.37	**39.25**
141	B9	16.400	7.388	**0.507**	40.43	**39.32**
191	B1	15.990	7.702	**2.044**	33.40	**33.32**
191	B2	15.990	7.702	**2.034**	32.58	**32.49**
191	B3	15.990	7.702	**2.014**	33.35	**33.26**
191	C1	15.990	7.702	**1.511**	35.35	**35.26**
191	C2	15.990	7.702	**1.504**	34.79	**34.69**
191	C3	15.990	7.702	**1.496**	35.28	**35.18**
191	D1	15.990	7.702	**1.005**	37.09	**37.00**
191	D2	15.990	7.702	**1.001**	37.49	**37.39**
191	D3	15.990	7.702	**1.003**	38.04	**37.94**
191	E1	15.990	7.702	**0.501**	39.73	**39.63**
191	E2	15.990	7.702	**0.501**	40.57	**40.46**
191	E3	15.990	7.702	**0.504**	39.38	**39.28**

SOTE(corr) = [SUBM(target) / SUBM(data)] x SOTE(data).
SCFM/KCF=[(SCFM/Disc)1000] / [AtAd(sqft/Disc)WaterDepth]
BOLD values indicated the data plotted on the attached graph.

INDEX OF SELECTED CERTIFIED OXYGEN TRANSFER TESTS:

Test	Date	Job #	Job Name
69	May-02	01-4853	Oceanside, CA
141	Aug-07	07-6567S	Tulsa, OK WWTP
191	Jan-11	10-7412S	Kalamazoo, MI - Additional Testing

SANITAIRE®

TABLE OF CONTENTS

SANITAIRE®

INSTALLATION AND START-UP

RECEIVING AND SITE STORAGE

Prior to equipment arrival a dry, level temporary storage site should be made available.

Shipments made within the USA, Canada and Mexico will be delivered on flat bed trailer trucks. Unload components with a forklift or crane.

An export shipment will arrive in export containers. On these containers, the top and one end are removable.

Palletized and banded air distributor sections and/or palletized and wrapped boxes of equipment components are placed at the bottom of the container. Loose manifold sections, droplegs or boxes are placed on the top.

Remove the loose boxes by hand. Remove the loose manifold sections and droplegs by hand or with a crane and sling device.

Palletized boxes of equipment components will be placed near the open end for removal by forklift. The palletized air distributor sections are removed by using a crane and wire slings placed through the lifting lugs as shown in Figure 0.

DO NOT stack these shipping units.

DO NOT store the units where snow removal or other heavy equipment could cause damage.

DO NOT cover the pipe components with plastic. Excessive heat build-up can damage plastic pipe and will void the equipment warranty.

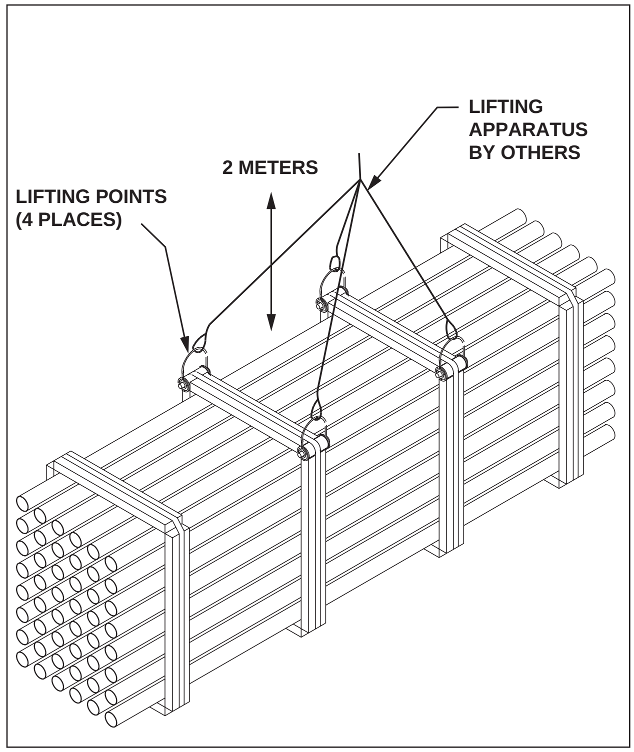


Figure 0

PHYSICAL INVENTORY

Sanitaire has provided shipping lists for all components used for the aeration system in this manual. In addition, each shipment has a packing list of all items delivered.

Before installation, take a physical inventory of all components (by comparing the shipping and packing lists) and immediately report any missing or damaged items to Sanitaire.

DROPLEG AND MANIFOLD INSTALLATION

1. Attach the upper stainless steel portion of the dropleg to the air main.

NOTE

When the upper dropleg is installed properly it should be vertical with it's centerline located as shown on the erection drawings. (See Figure 1) The droplegs are shipped with protective end plugs which require removal prior to installation.

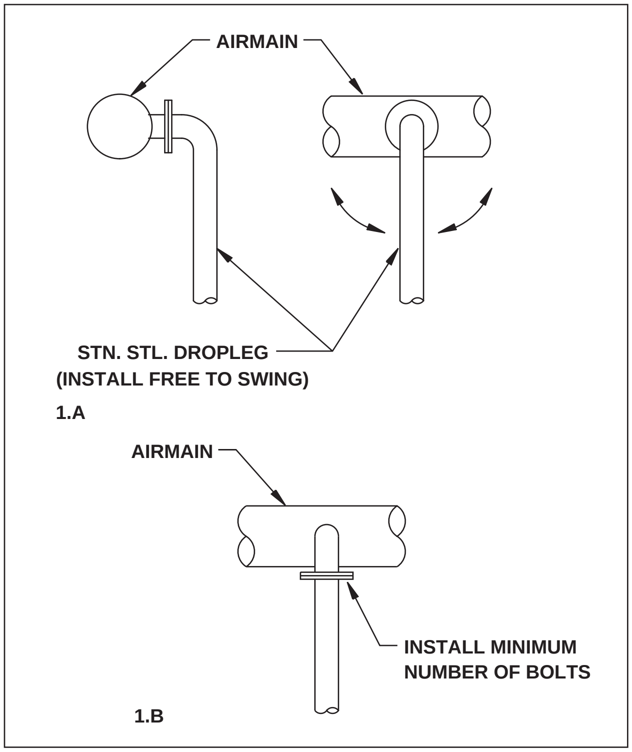


Figure 1

The air main must be capable of supporting the full weight of the upper stainless steel portion of the dropleg.

CAUTION

Before installing the upper dropleg section, all dirt and debris must be removed from the air main. The air blowers are normally used for this operation. Air filtration equipment should be installed and operating prior to blowing out air lines. Blowers may require a minimum back pressure when operating. Be sure to follow manufacturer's requirements.

NOTE

A) *Droplegs with a top connecting elbow, as shown in Figure 1.A, should be bolted and tightened to the air main connection to a point which will allow the dropleg to be swung to the side when installing the lower PVC portion of the dropleg.*

B) *Droplegs with a horizontal flange connection, as shown in Figure 1.B, should be temporarily bolted tightly to the air main connection with a minimum number of bolts. The dropleg will have to be removed to install the lower PVC portion of the dropleg.*

2. Use the installed stainless steel upper dropleg and the erection drawings to locate and layout the centerline of the aeration grid manifold.

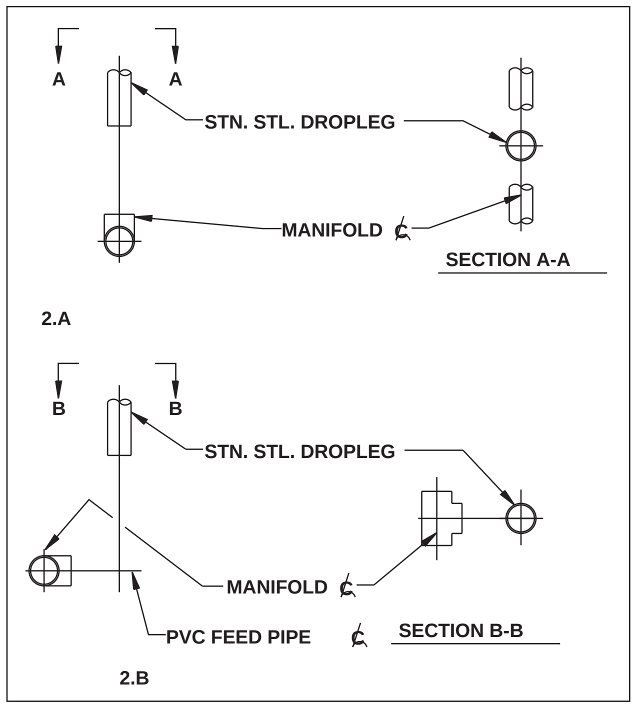
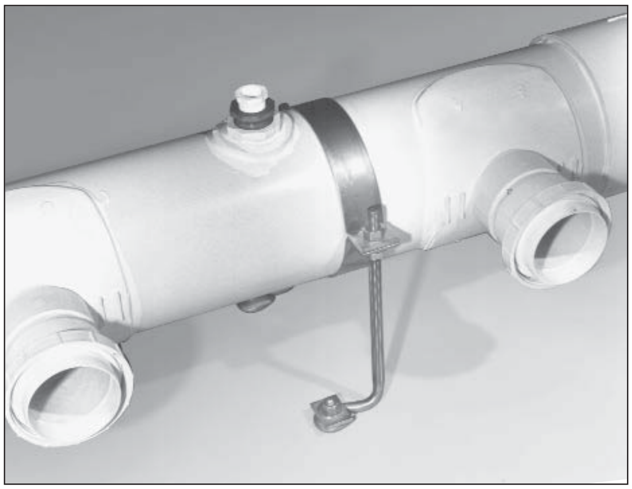
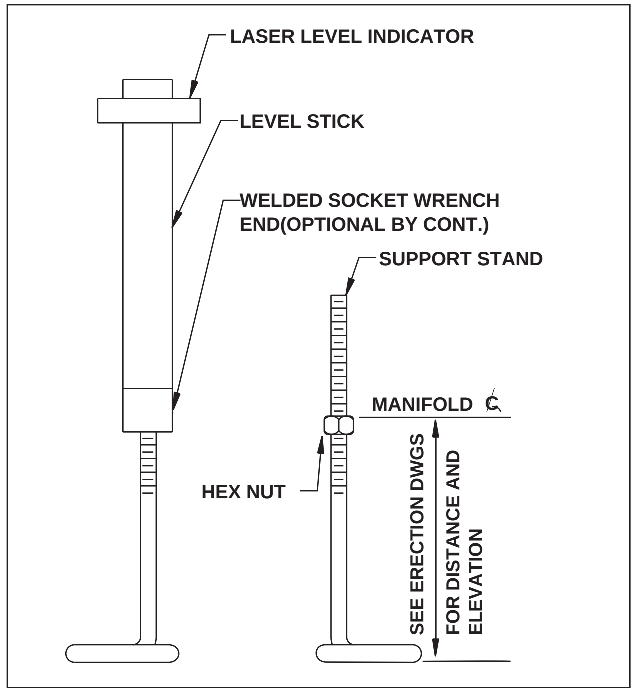


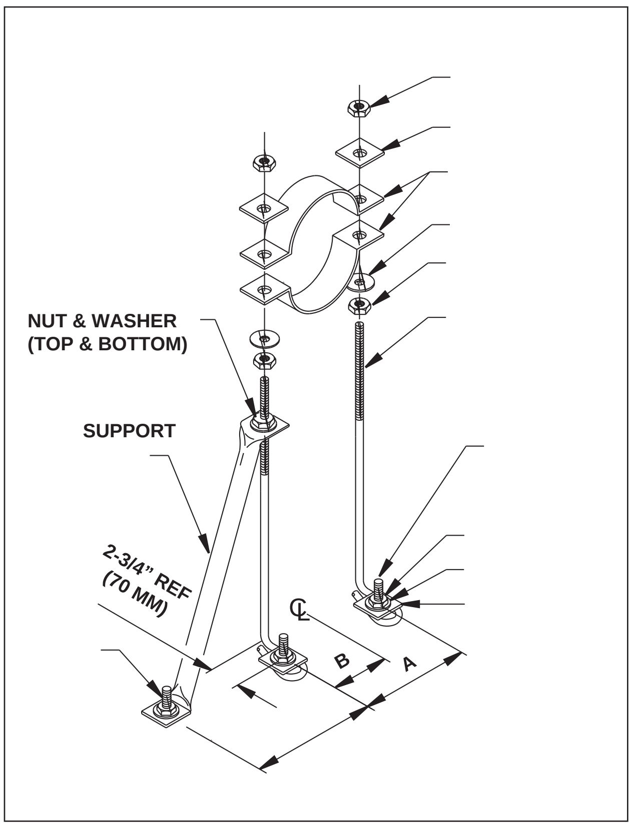
Figure 2

NOTE

The dropleg connection on the manifold is a PVC socket tee or elbow. This connection can be located directly under the dropleg as shown in Figure 2.A or offset as shown in Figure 2.B. Review the erection drawings prior to manifold layout.




LASER LEVEL INDICATOR
LEVEL STICK
WELDED SOCKET WRENCH END(OPTIONAL BY CONT.)
SUPPORT STAND
MANIFOLD ℄
HEX NUT
SEE ERECTION DWGS FOR DISTANCE AND ELEVATION


NUT & WASHER (TOP & BOTTOM)
SUPPORT
2-3/4" REF (70 MM)
℄
B
A

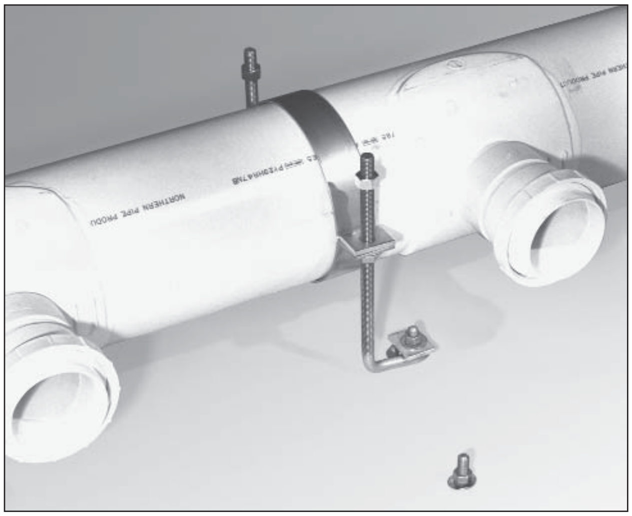


Figure 8

10. Install the upper half of the pipe clamp, plate washers and nuts. **Do not secure at this time.** See Figures 5, 8 and the erection drawings.

11. Level the manifold section which attaches to the dropleg so that the air distributor connections are plumb vertically for raised manifolds or level horizontally for in-line manifolds. See Figures 9 and 10.

12. Secure the pipe clamps on this section by tightening down the hex nuts on the top pipe clamp. Make sure the manifold pipe is level in a horizontal line parallel to the centerline.

Figure 9

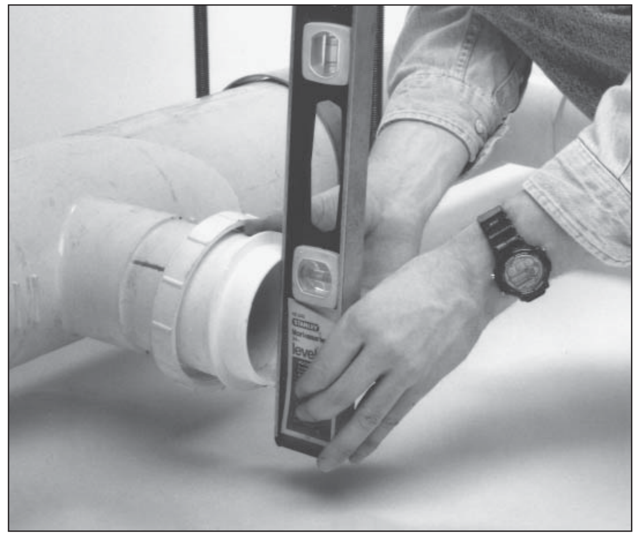


Figure 10

13. Using the following procedure, install the lower PVC portion of the dropleg:

A) With a heavy body solvent cement, field glue all required PVC feed pipe and fittings up to the last "cut to fit pipe section" which mates to the stainless steel upper dropleg section. See Figure 11 and the erection drawings. Install feed pipe supports as required and shown on the erection drawings.

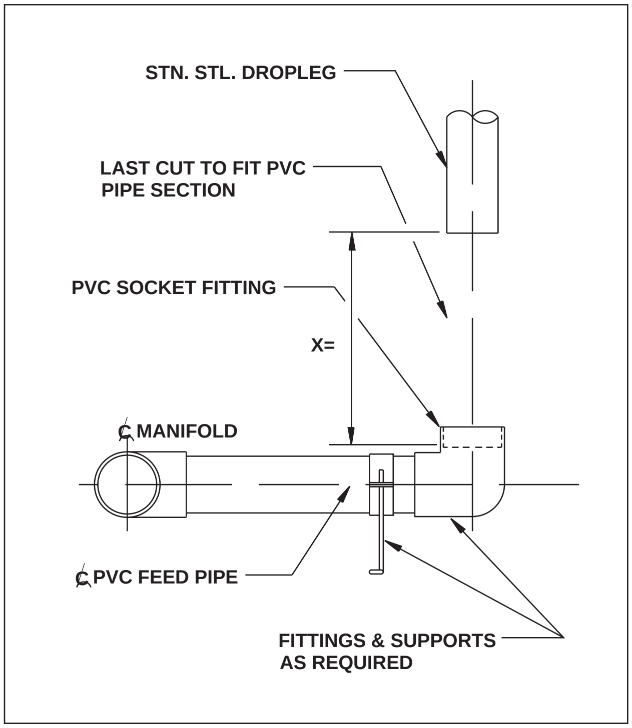
NOTE

Manifolds where the upper stainless steel dropleg is positioned directly in-line with the manifold connection as shown in Figure 2.A, ***DO NOT*** *require a feed pipe, fittings and supports.*

B) Measure the distance "X" from the end of the installed stainless steel upper dropleg to the insertion depth of the PVC socket fitting. See Figure 11.

C) Remove or swing the upper stainless steel portion of the dropleg out of the work area.

D) Cut or trim the lower PVC dropleg to the measured distance.


STN. STL. DROPLEG
LAST CUT TO FIT PVC
PIPE SECTION
PVC SOCKET FITTING
X=
℄ MANIFOLD
℄ PVC FEED PIPE
FITTINGS & SUPPORTS
AS REQUIRED


MIN. WALL-.125

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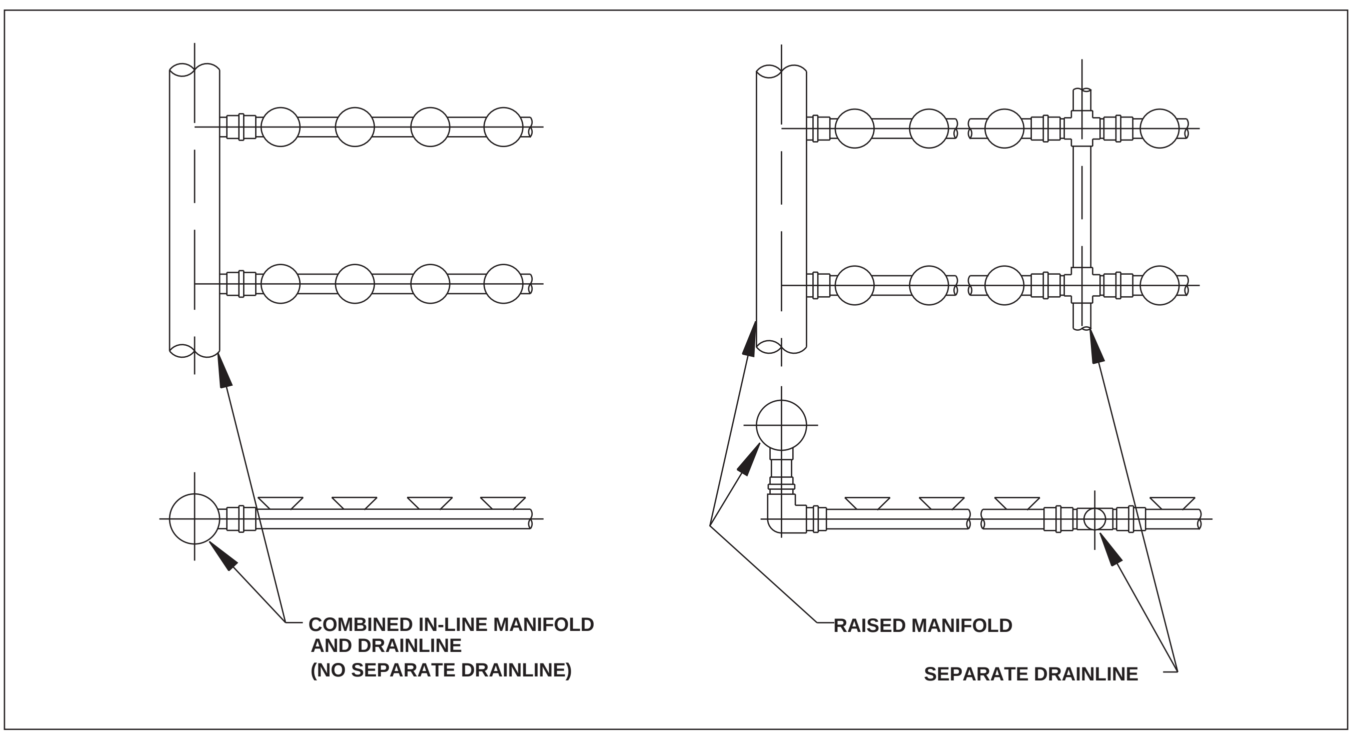
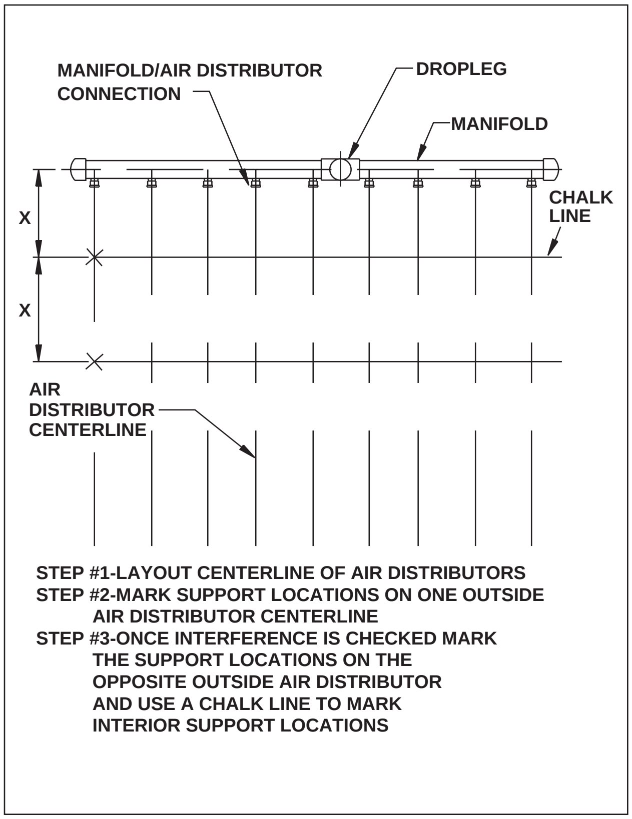
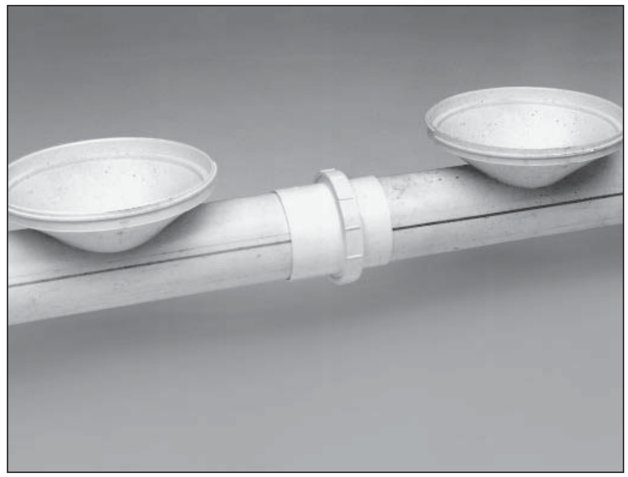
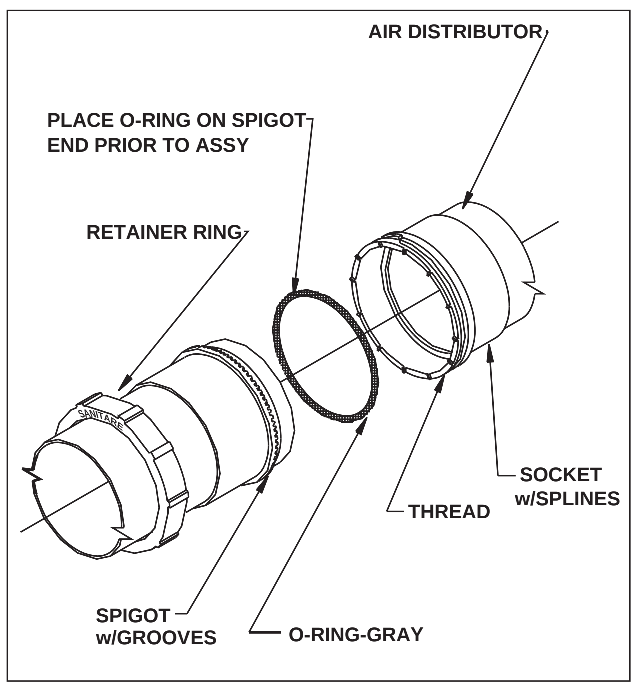

COMBINED IN-LINE MANIFOLD
AND DRAINLINE
(NO SEPARATE DRAINLINE)
RAISED MANIFOLD
SEPARATE DRAINLINE

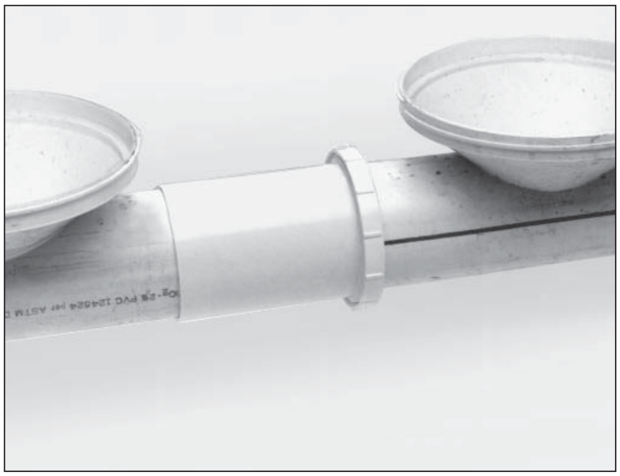
SANITAIRE®

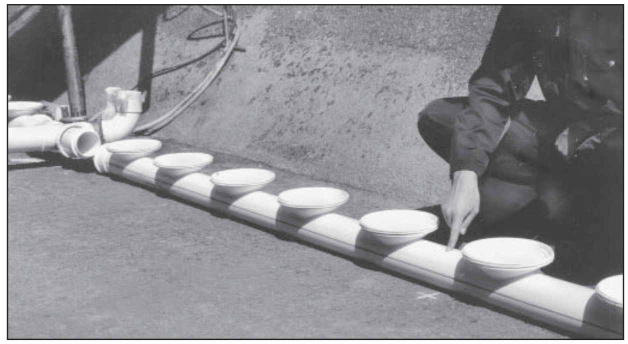

MANIFOLD/AIR DISTRIBUTOR CONNECTION
DROPLEG
MANIFOLD
CHALK LINE
X
X
AIR DISTRIBUTOR CENTERLINE
STEP #1-LAYOUT CENTERLINE OF AIR DISTRIBUTORS
STEP #2-MARK SUPPORT LOCATIONS ON ONE OUTSIDE AIR DISTRIBUTOR CENTERLINE
STEP #3-ONCE INTERFERENCE IS CHECKED MARK THE SUPPORT LOCATIONS ON THE OPPOSITE OUTSIDE AIR DISTRIBUTOR AND USE A CHALK LINE TO MARK INTERIOR SUPPORT LOCATIONS

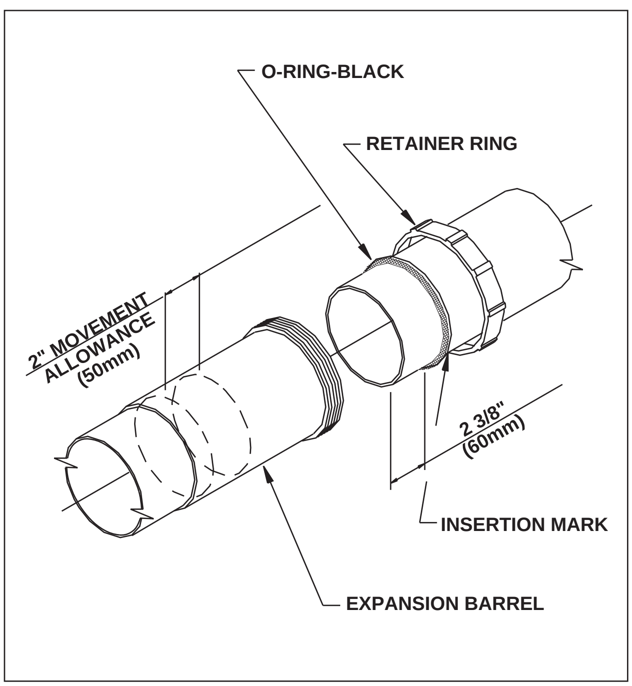

33-1




AIR DISTRIBUTOR
PLACE O-RING ON SPIGOT END PRIOR TO ASSY
RETAINER RING
SANITAIRE
SOCKET w/SPLINES
THREAD
SPIGOT w/GROOVES
O-RING-GRAY






O-RING-BLACK
RETAINER RING
2" MOVEMENT
ALLOWANCE
(50mm)
2 3/8"
(60mm)
INSERTION MARK
EXPANSION BARREL

All 4" Ø (100 mm) manifolds will use 1/2" Ø supports regardless of location.

Anchor Supports — (see Figures 24, 26A and 26B.) Anchor supports are used after expansion joints. The anchor support has 1/2" Ø rods and a 5-1/4" (133 mm) center to center rod distance. The clamps are heavy gauge stainless and will clamp down tight on the pipe. Modifications to the anchor support will be used if the air distributor centerline exceeds 5" (127 mm) from the floor and may be the pedestal type as shown in Figure 26A or have stiffening struts applied as shown in Figure 26B.

A-Frame Supports — (see Figures 27A and 27B.) A-frame supports are a formed stainless structure that could be a fixed support as shown in Figure 27A or a guide type non-gripping support as shown in Figure 27B.

The A-frame can be used in areas of high turbulence, extreme floor slope or on end looped drainlines.

General Notes on Air Distributor Support Installation

A) Use the correct support at the proper location. See erection drawings.

B) Sloped floors may require the use of several different support types and support rod diameters. See erection drawings.

C) The rod type support base locating plate must be installed as shown per Figure 25. Tighten the hex nut to the recommended torque value as listed by the anchor bolt manufacturer in their installation instructions.

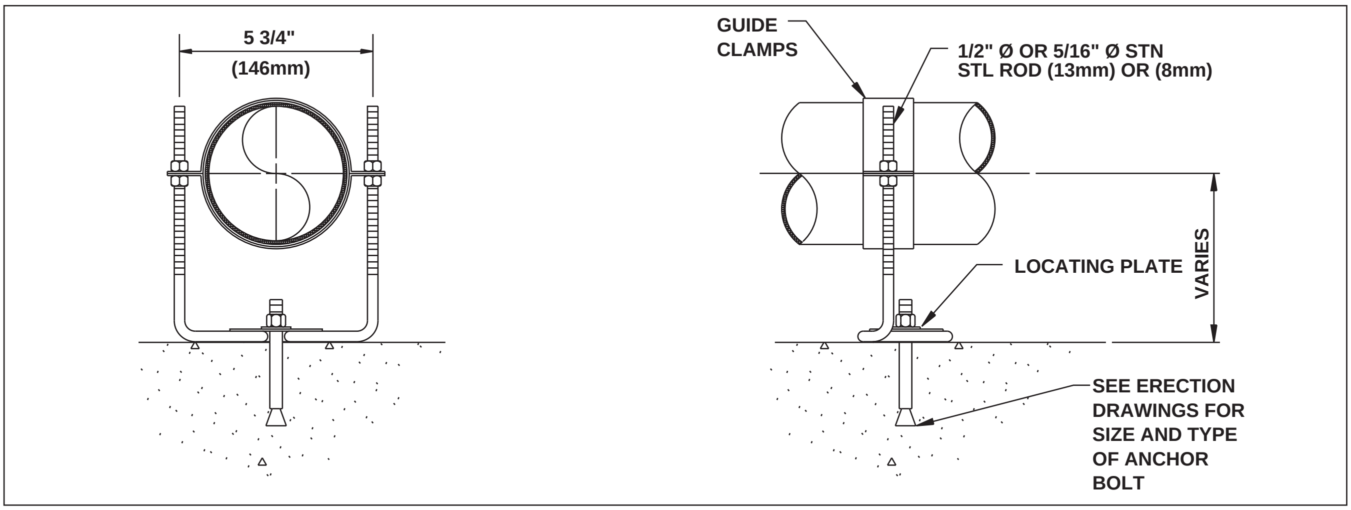


Figure 23

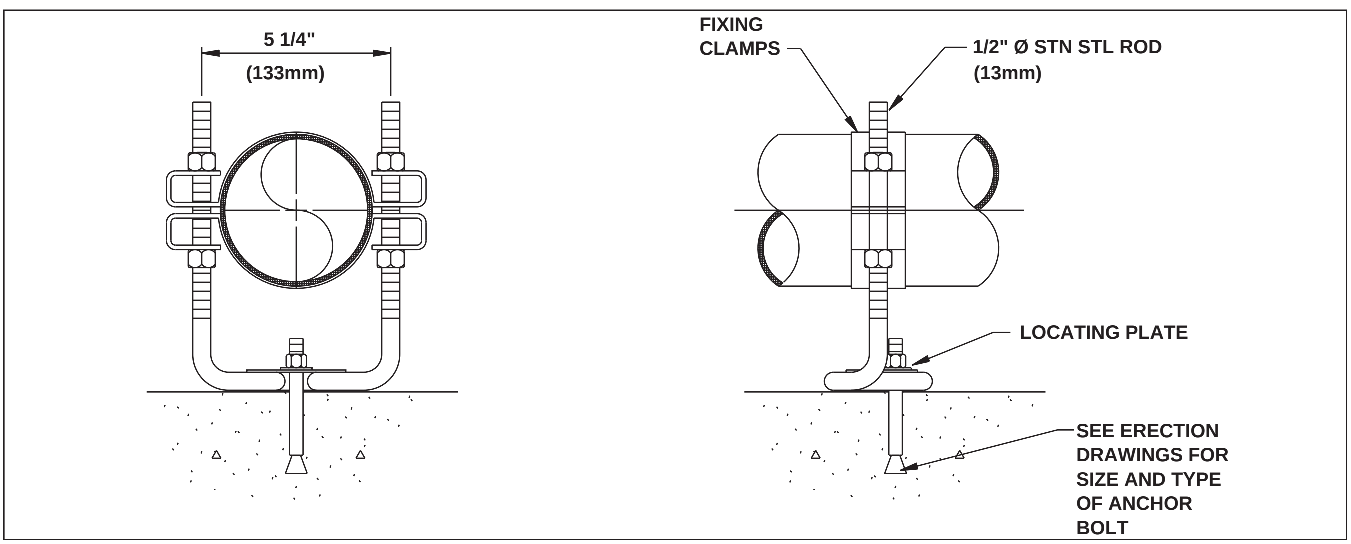
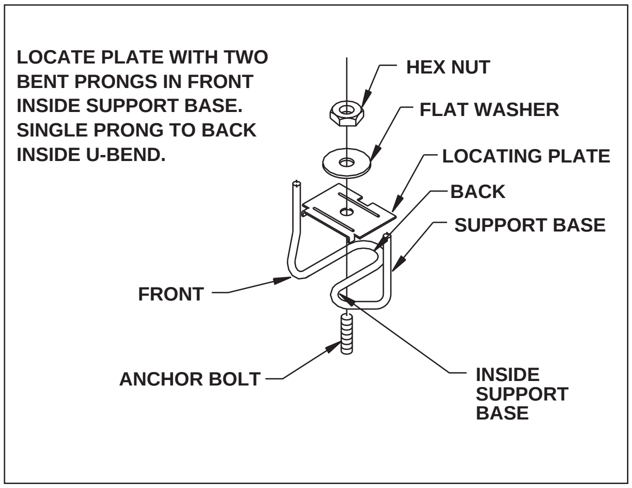
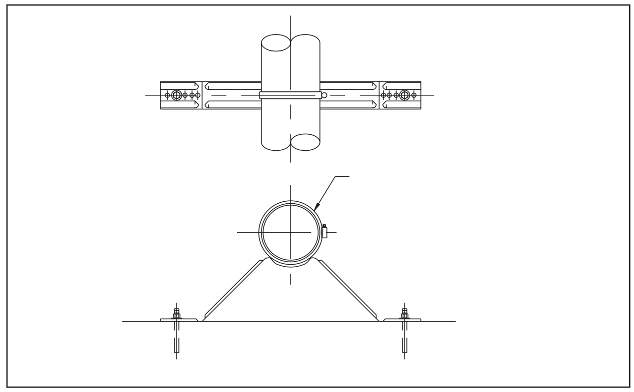
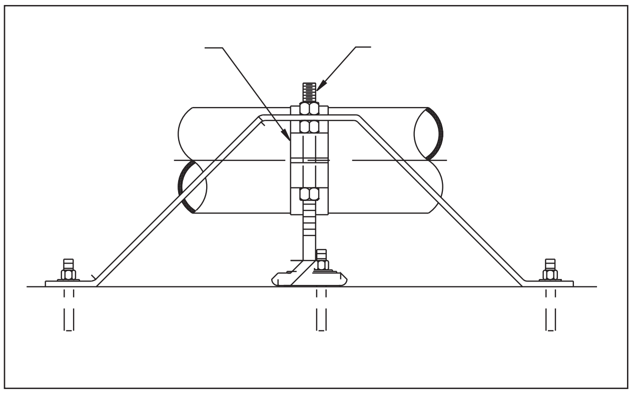
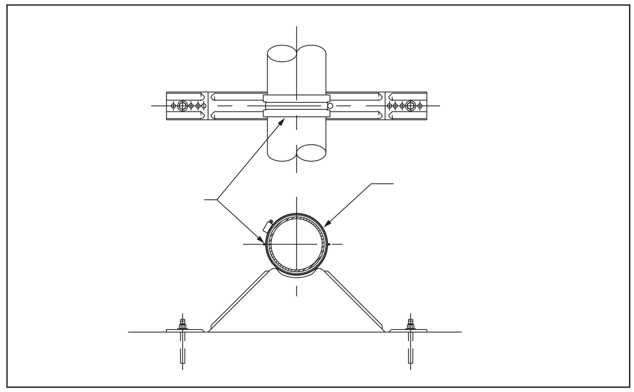


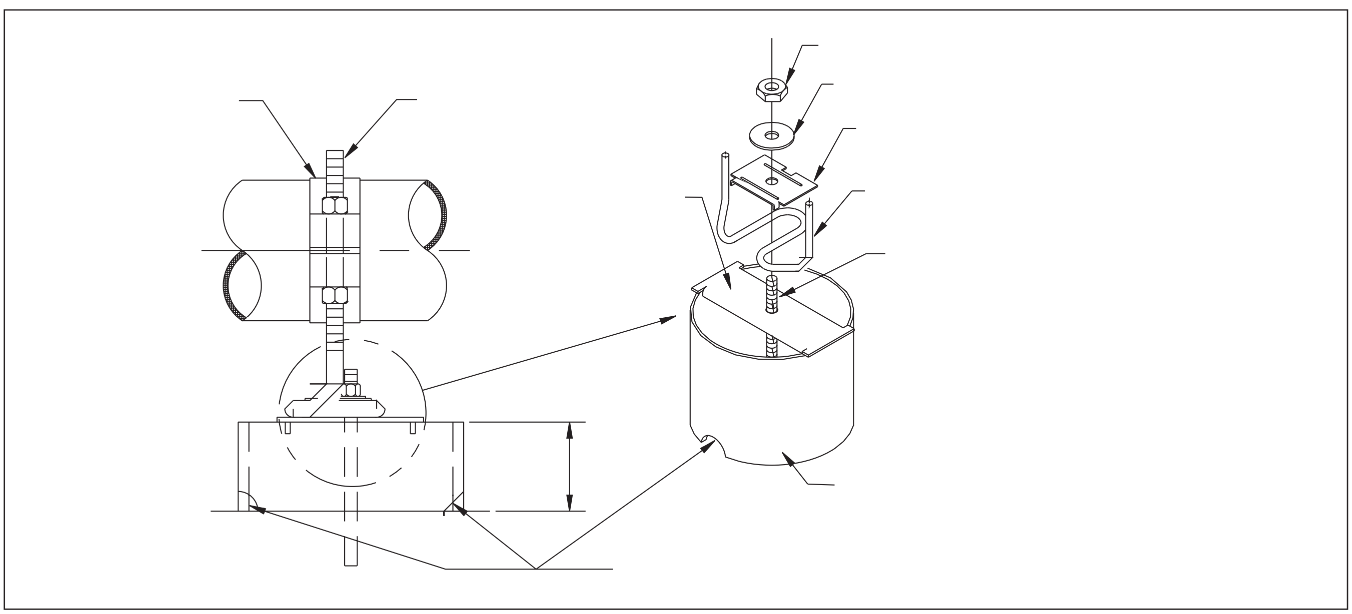
Figure 24

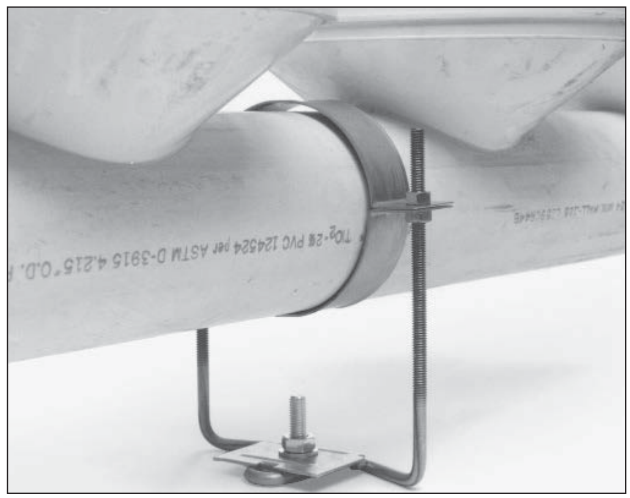

LOCATE PLATE WITH TWO
BENT PRONGS IN FRONT
INSIDE SUPPORT BASE.
SINGLE PRONG TO BACK
INSIDE U-BEND.
HEX NUT
FLAT WASHER
LOCATING PLATE
BACK
SUPPORT BASE
FRONT
ANCHOR BOLT
INSIDE
SUPPORT
BASE











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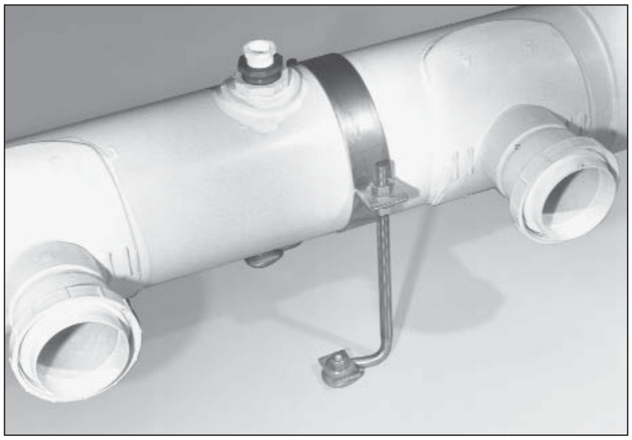
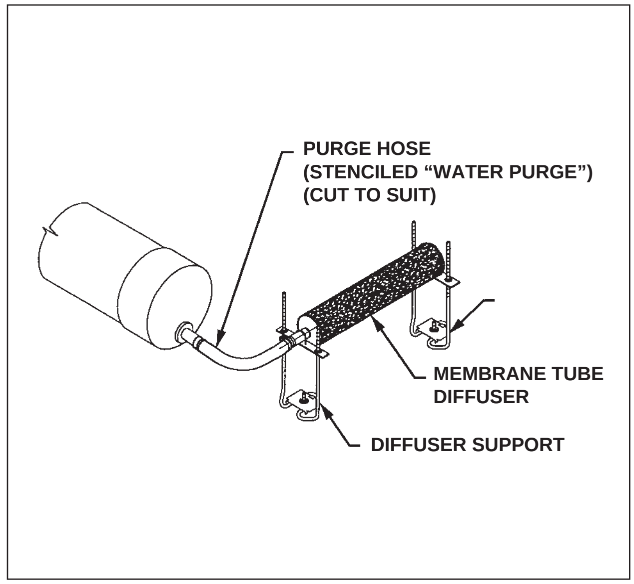
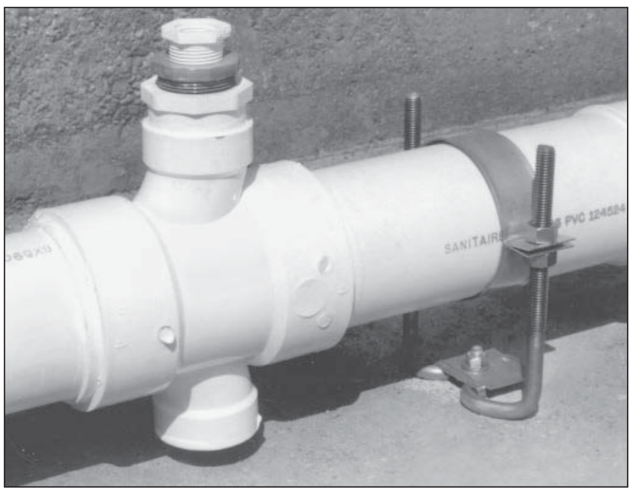



PURGE HOSE
(STENCILED “WATER PURGE”)
(CUT TO SUIT)
MEMBRANE TUBE
DIFFUSER
DIFFUSER SUPPORT


SANITAIRE
PVC 124524

To Install CERAMIC DISC diffusers:

1. Set the diffuser disc in the holder with the dished side and peripheral stepped edge up.

2. Lubricate the diffuser “O”-ring with a small amount of the lubricant provided by Sanitaire.

3. Place the diffuser “O”-ring in the slot or void between the diffuser holder vertical wall and the raised portion of the diffuser disc. See Figure 33.

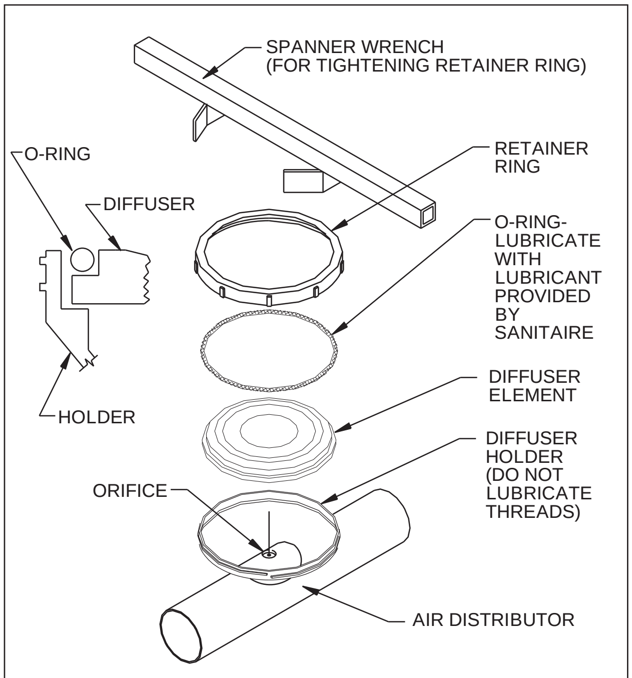


Figure 33

4. Turn the retaining ring to a hand-tight position making sure the “O”-ring stays in place.

5. Using the retaining ring spanner wrench, turn the retaining ring an additional 1/4 turn. See Figure 34.

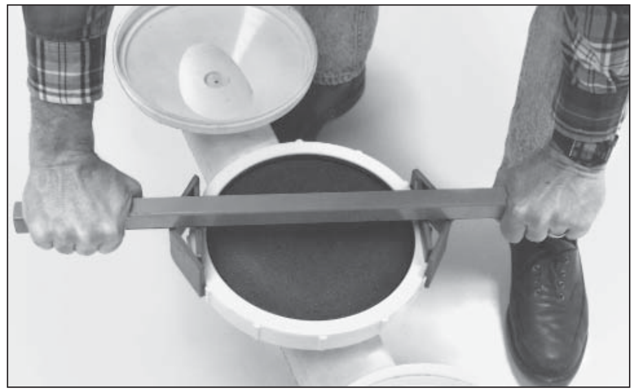


Figure 34

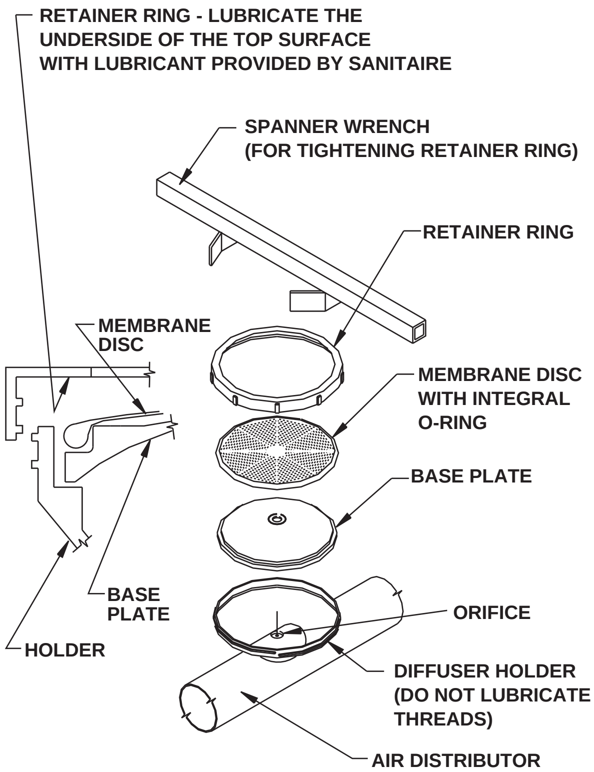
To Install MEMBRANE DISC diffusers:

1. Set the diffuser PVC subplate in the diffuser holder with the flat side up. See Figure 35.

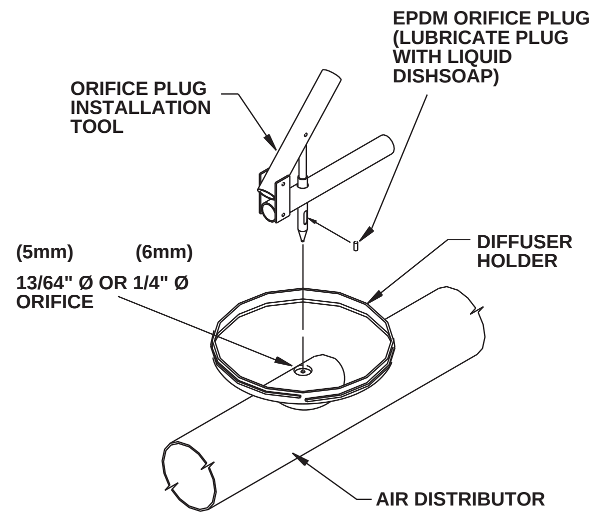
Figure 35

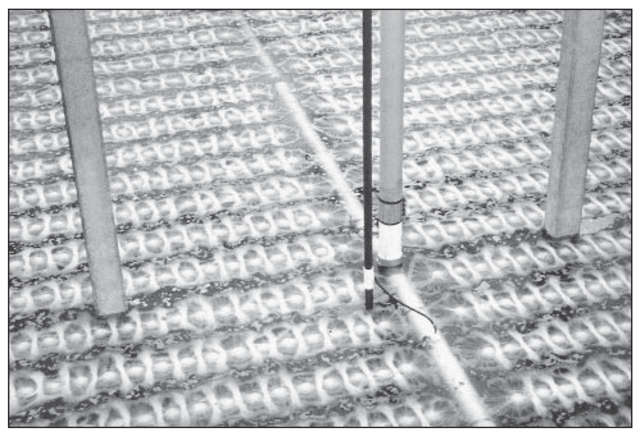
2. Place the membrane disc over the subplate. The integral “O”-ring should naturally fit down into the void created between the diffuser holder vertical wall and subplate.

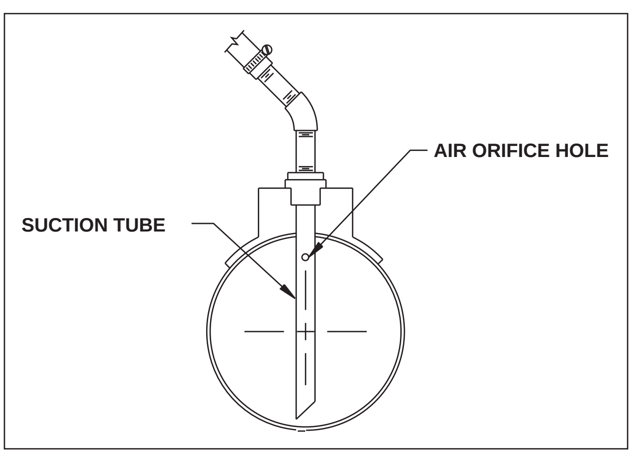
3. Lubricate the diffuser retaining ring with a small amount of lubricant provided by Sanitaire by turning the ring upside down and swabbing the lubricant on the underside of the top surface of the retaining ring. See Figure 36.



MEMBRANE DISC







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on AIR side:

- Dust and dirt from unfiltered or inadequately filtered air.
- Rust and scale from air main corrosion.
- Oxidation and subsequent flaking of bituminous air main coatings.
- Construction debris
- Mixed liquor solids entering through system leaks or cracks.

Several ways of determining if the diffusers are fouled are discussed in the preventative maintenance section of this manual.

The corrective action for fouled diffusers is cleaning. This is discussed in the yearly maintenance and diffuser cleaning section of this manual.

PREVENTATIVE MAINTENANCE

MOISTURE PURGE

Moisture enters the pipe system in three ways:

- Condensate build-up inside the pipe system due to high blower discharge temperatures and moist or humid air (primary cause).
- Minor leaks in the pipe system.
- Back flow through ceramic diffusers caused by a loss of air.

NOTE

Membrane diffusers are designed to seal on the subplate and prevent moisture from entering the system.

The effects of entrapped moisture are:

- Increased air velocity and headloss.
- Poor air distribution.

Sanitaire manufactures two types of purge systems: a standard, manually operated system (most common) and a continuous purge system.

The standard system uses a sump with an eductor line that extends from the grid to above the water surface and ends with a manual ball valve. To operate this system simply open the ball valve and the trapped liquid will be purged from the system. Close the valve when the water flow stops and a mist appears.

NOTE

For maximum purge results, lower the air flow to the grid. The air velocity will be reduced and more of the liquid will be forced to the sump.

The purge frequency is site determined; however, once a week is a good rule of thumb.

The second type of purge system is the continuous purge system which employs a diffuser unit attached to the bottom of the manifold or drainline. The entrapped moisture is continuously purged from the system.

The continuous purge systems are used on grids where it is not possible to reach a purge valve safely from a walkway.

AIR BUMPING

Air bumping is a technique that can be employed by operators to temporarily reduce back pressure in the system. Air bumping is the act of increasing the air flow rate per diffuser for 20-30 minutes once per week. An air rate per diffuser of 3 Scfm (5 m^3/hr) is generally used.

This practice will aid in sloughing off settled debris and may extend the period between diffuser cleanings.

POWER FAILURES AND LOSS OF AIR SUPPLY

The results of a power failure (loss of air supply) on each diffuser type are as follows:

for CERAMIC DISC diffusers:

- Solids settle on diffuser surface.
- Filtered mixed liquor penetrates the diffuser and enters the pipe network.
- Short term affect: none.
- Long term affect: fouling may occur on the surface and within the diffuser disc.

When the air supply is restored, the air pressure will build and the flow will reduce until sufficient water is pushed out of the system to allow air to be released through the diffusers.

NOTE

It is suggested that the operator open the purge valves as soon as possible after a power outage and evacuate the system. If the liquid is left in the system the flow will be reduced and the operating pressure will be higher than normal.

for MEMBRANE DISC diffusers:

- Solids settle on diffuser surface.
- Short term affect: none.
- Long term affect: the potential of surface fouling is possible and the diffusers may require a cleaning. This is generally the case for long term intermittently used membrane disc systems (i.e., Anoxic Zones, Batch Reactors).
- May require operator to shut off adjacent grids or turn on additional blowers to increase the air flow rate and force the membrane off the subplate surface. This is again generally the case for long term intermittently used membrane disc aeration systems.

VISUAL INSPECTION

Visually inspect the aeration basin surface pattern. The flow should be, for the most part, a nice quiescent pattern. Some coarse bubbling at the basin inlet may occur due to surfactants in the wastewater and is generally dispersed shortly downstream.

Excessive coarse bubbling throughout the tank indicates the diffusers may be fouling.

Large boiling in an isolated area indicates a failure in the submerged pipe system.

Visual inspection is an ongoing preventative maintenance step and can be done while taking routine samples, dissolved oxygen readings, etc.

AIR MAIN INSPECTION

Air main leaks are easily identified and usually are caused by loose joints or degraded gaskets. These types of leaks should be repaired quickly in order to prevent loss of system efficiency.

OPERATING PRESSURE AND AIRFLOW

Most blower systems are equipped with discharge pressure gauges. The operator should keep a regular log of pressure readings. A continuous increase in operating pressure indicates diffuser fouling. Likewise, a continuous increase in air demand without a change in the aeration basin loading indicates diffuser fouling.

Fine Bubble Grid Aeration System
TROUBLESHOOTING GUIDE

Problem	Cause	Action
VISUAL INSPECTION		
Poor air distribution	Diffusers not level	Level system
	Grid flooded	Operate grid purge system
	Plugged orifice	Clean orifice
	Insufficient air	Provide more air
	Solids settling	Provide more air to grid
Visible mounding of air in one location	Broken pipe	Repair (see repair procedures)
Coarse bubbling (large bubbles)	Diffuser fouling	Clean diffusers (see cleaning procedure)
Air discharge from air main	Loose joints, degraded gaskets, or degraded air main	Repair as required
OPERATIONAL PROBLEMS		
Low D.O. Concentration	Too little air	Increase air flow
High D.O. Concentration	Too much air	Decrease air flow
		Decrease quantity of diffusers in service
Increased operating pressure	Diffuser fouling	Clean diffusers (see cleaning procedure)
	Line blockage or valve closed	Check air lines and valves
Increased air requirement/ no load change	Diffuser fouling	Clean diffusers (see cleaning procedure)
	Leak in air system	Inspect and repair as required

WARNING:

Prior to draining a tank, please READ these instructions carefully to minimize the potential for heat related damage to the Aeration System.

BASIN DRAINING PROCEDURE

Before draining a basin for diffuser inspection, tank cleaning or other maintenance operations, do the following:

- Place the basin in a manual mode to override any automatic D.O./blower control systems.
- Adjust the grid(s) air control valve(s) to deliver an air flow rate equivalent to 0.5 scfm per diffuser or to a 25% open position if air flow metering is not available.
- AERATION TANK - Stop all flow to the basin.
- AEROBIC DIGESTER - Stop all flow to the basin.
- Turn off the air completely to the basin when the liquid level reaches 1 to 2 Ft. above the diffusers.
- When cleaning diffusers, the air can be turned on for short periods of time for the grid being cleaned.

NOTE: As the basin is draining, monitor the amount of air flowing to the submerged grid(s). **THE AIR FLOW SHOULD BE KEPT TO A MINIMUM. THIS WILL PREVENT EXCESS HEAT BUILD-UP FROM DAMAGING THE PVC OR CPVC PIPING SYSTEM WHILE KEEPING THE SOLIDS IN SUSPENSION.**

Refer to pages 27 and 28 for Diffuser Cleaning Procedure.

YEARLY MAINTENANCE AND DIFFUSER CLEANING

MAINTENANCE SCHEDULE

Sanitaire recommends the following maintenance schedule be observed at least once per year.

1. Drain down each tank.
2. Remove excess settled solids if any have accumulated.
3. Clean diffusers.
4. Inspect support hardware to ensure all components are intact and tight.
5. Inspect diffuser retaining rings to make sure all rings are in place and tight.
6. Inspect fixed and expansion joint retaining rings to make sure all rings are tight.

NOTE

For items 4-6, refer to the Installation Instructions.

LUBRICATION SCHEDULE

Since there are no moving parts on the SANITAIRE Fine Bubble Aeration Systems, a formal lubrication schedule is not required.

Three components require lubrication at the time of initial installation and future repairs. These components are:

- Ceramic Disc Diffuser "O"-Ring
- Membrane Disc Diffuser Retaining Ring
- Expansion Barrel, 4" Ø black "O"-Ring

Lubricate these items with the lubricants provided by Sanitaire and in accordance with the Installation Instructions.

CERAMIC DISC DIFFUSER CLEANING METHOD

1. Drain aeration basin (the air should remain on as basin is drained).
2. With the air left on – at approximately 1 scfm (1.7 m^3/hr) per diffuser – hose off each disc for twenty seconds with clean water at a nozzle pressure of 60 psig. Turn off the air supply when completed.
3. Put on the following safety equipment: eye goggles, rubber gloves, boots, sleeves, and apron. A breathing apparatus should be available in the event it is needed.

⚠ **CAUTION**

Acid can be harmful if misused. Follow all manufacturers precautions and directions. Wear appropriate safety equipment. Do not breath acid vapors. Do not allow acid to make contact with eyes, skin or hair.

4. Carefully prepare a 50% by volume solution of 18° baume muriatic acid. Always add the acid to water.
5. Using an acid resistant compression sprayer, apply a uniform covering of the acid solution to all diffuser elements.

NOTE

Do not spray the acid solution on the stainless steel supports and hardware.

6. Allow the acid solution to sit on the diffusers for 30 minutes.
7. Turn the air back on at a rate of 1 scfm (1.7 m^3/hr) per diffuser and repeat the hosing procedure for 10 seconds per diffuser.
8. Inspect the aeration system to determine if any hardware was loosened or broken during the cleaning.

9. Review and follow the start-up procedure as found in the Installation and Start-up Section of this manual.

MEMBRANE DISC DIFFUSER CLEANING METHOD

1. Drain aeration basin (the air should remain on as basin is drained).

2. With the air left on at approximately 1 scfm (1.7 m^3/hr) per diffuser, hose off each disc for twenty seconds with a clean water source at a nozzle pressure of 60 psig.

3. Turn off the air flow to the aeration grid being cleaned.

4. If required, use a rag or soft bristle brush to scrub each diffuser to remove stubborn slime growth, chemical precipitates, or oils. Do not use acids or aggressive cleaners.

5. Turn the air back on at a rate of 1 scfm (1.7 m^3/hr) per diffuser and repeat the hosing procedure for 10 seconds per diffuser.

6. Visually inspect the aeration system to determine if any hardware was loosened or broken during cleaning.

7. Review and follow the start-up procedure as found in the Installation and Start-up Section of this manual.

LONG TERM STORAGE PROCEDURES

The following storage procedures are applicable to both fine bubble ceramic and membrane disc aeration systems.

The four options below were developed to protect the PVC pipe and diffusers from environmental damage, and are listed in order of preference.

NOTE

Prior to reading and determining a suitable long term storage method, it should be understood that Sanitaire assumes no responsibility for damage and cleaning requirements as a result of long term storage.

OPTION #1

For use when the aeration system is not in use and air is available.

For warm climate storage:

1. Fill the tank with clean water to a level three feet above the PVC portion of the dropleg. This will give the pipe and diffusers protection from UV light and heat build-up.

2. Run a small amount of air through the system to keep the pipes empty and retard the growth of algae on the diffusers.

3. Chlorinate initially and periodically as algae appears in the water.

4. Prior to bringing the system on line, drain and check all hardware. Check the diffusers and clean if fouling is evident.

For cold climate storage:

1. Follow warm climate procedures above after performing the following:

2. Prior to filling with water, install styrofoam blocks around the dropleg and carrier columns installed in the tank. These blocks will prevent crushing should ice build-up around the pipes.

NOTE

The operator may have to adjust the air flow rate to a higher level to prevent ice formation during severe cold temperatures.

OPTION #2

For use when the aeration system is not in use, air is not available, and diffusers are removed prior to storage.

For warm climate storage:

1. Remove all diffusers, "O"-rings, retaining rings, sub plates, etc.; clean as required, and store in a clean, dry environment.

2. Fill the tank with clean water to a level three feet above the PVC portion of the dropleg.

3. Chlorinate initially and periodically as algae appears in the water.

4. Prior to bringing the system on line, drain and check all hardware. Check all diffuser holders and spot check pipe internals for algae growth and fouling. Clean as required prior to installing the diffusers.

For cold climate storage:

1. Remove all diffusers, "O"-rings, retaining rings, sub plates, etc.; clean as required, and store in a clean, dry environment.

2. Install styrofoam blocks around the dropleg and carrier columns installed in the tank.

3. Fill the tank with clean water to a level three feet above the PVC portion of the dropleg.

CAUTION

Water will freeze in the tank. ***Do not*** *drain the water from below the ice layer. Falling ice will crush the PVC pipe system.*

4. Wait until ice is completely off the tank prior to bringing the system on line. Check all diffuser holders and spot check pipe internals for algae growth and fouling, and clean as required prior to installing the diffusers.

OPTION #3

For use when the aeration system is not in use, air is not available, and diffusers are not removed prior to storage.

The procedure here is identical to Option #2 except that the diffusers are **not removed**. This procedure applies to Idle Tanks Only. Intermittent use membrane disc systems in a flowing condition have been previously discussed in the Plant Operation and Preventative Maintenance sections of this manual.

NOTE

Be aware that the diffusers will most likely need to be cleaned prior to putting the system on line. In addition to spot checking the pipe internals, the underside of the diffuser should be spot checked to determine the extent of fouling, and if cleaning is required prior to use.

OPTION #4

For use when the aeration system is not in use, air is not available, diffusers are not removed, and flooding is undesirable.

1. Drain tanks dry.

2. Open fixed joints and loosen support band clamps as required in order to roll the air distributor sections over 180˚.

NOTE

The fixed joints and floor drains should remain open to prevent water from standing in the pipe system and tank. Equipment flooded by overflows, misdirected sewage flows and excessive airborne dirt build-up will most likely require cleaning prior to being placed in service.

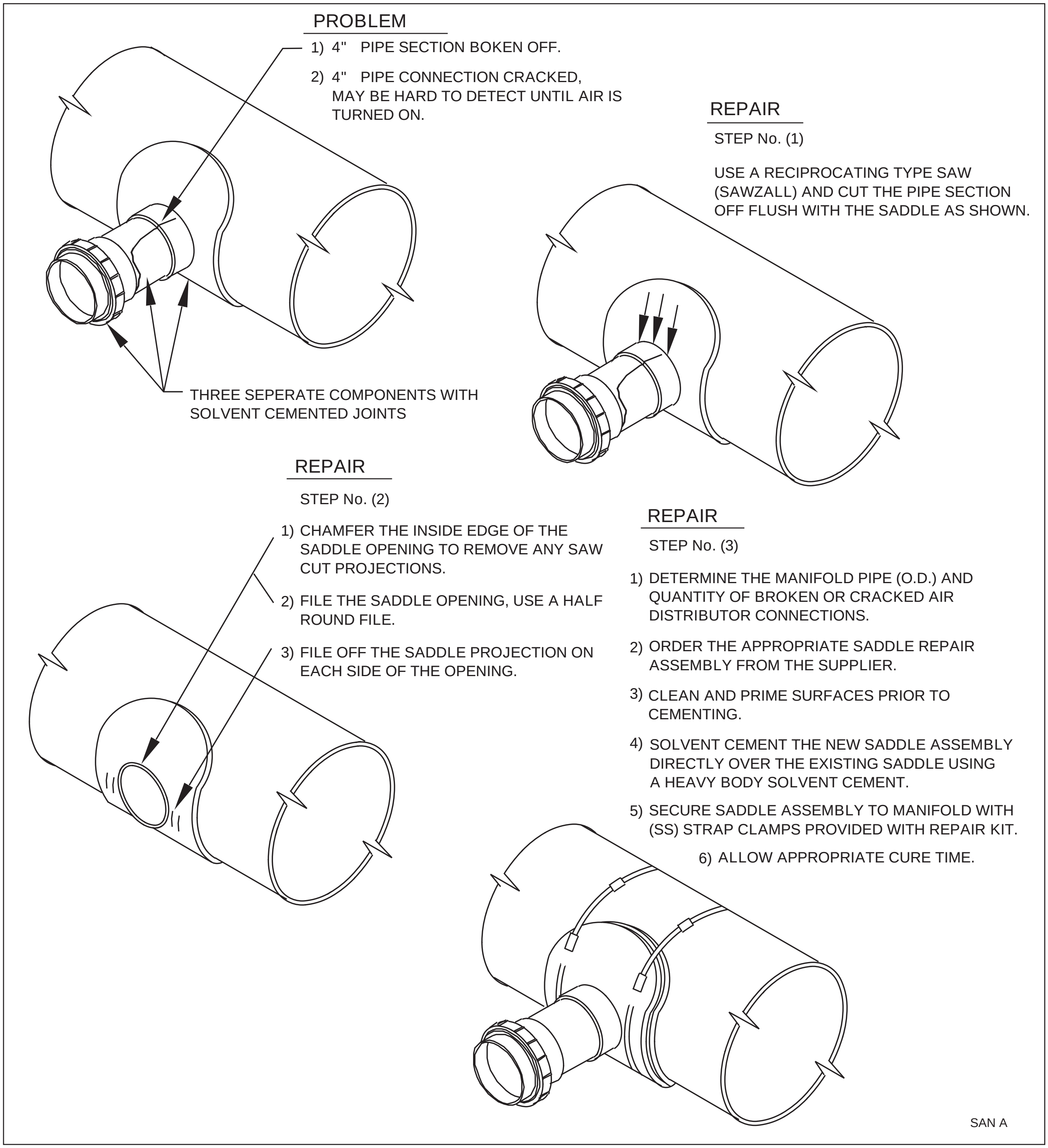
CAUTION

The pipe will be exposed to UV light degradation and heat build-up in the tank bottom which may cause warping and loss of some structural properties.

CAUTION

Standing water allowed to freeze around the pipe may break the pipe or may cause the diffusers (ceramic) to crack.

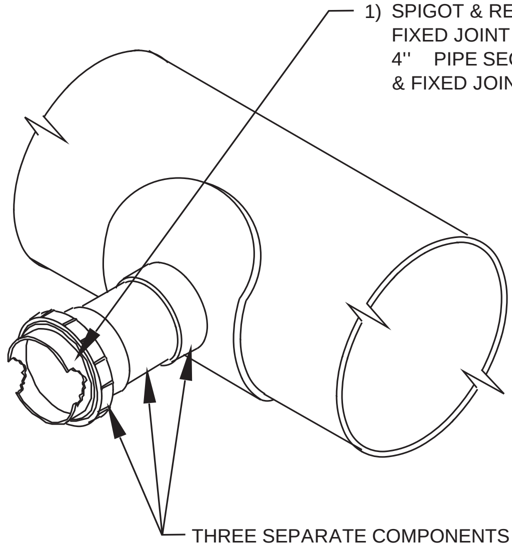
PIPE REPAIR PROCEDURES



MANIFOLD REPAIR – AIR DISTRIBUTOR CONNECTION SADDLE REPLACEMENT ON A 3-PIECE FABRICATED SADDLE ASSEMBLY

PROBLEM

1) SPIGOT & RETAINING RING END OF FIXED JOINT DAMAGED.
4'' PIPE SECTION BETWEEN SADDLE & FIXED JOINT IS NOT DAMAGED.

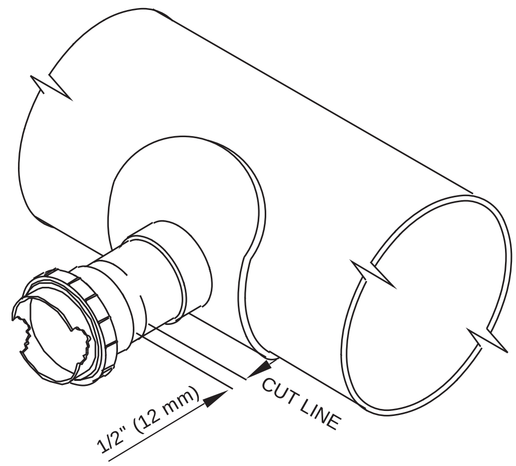


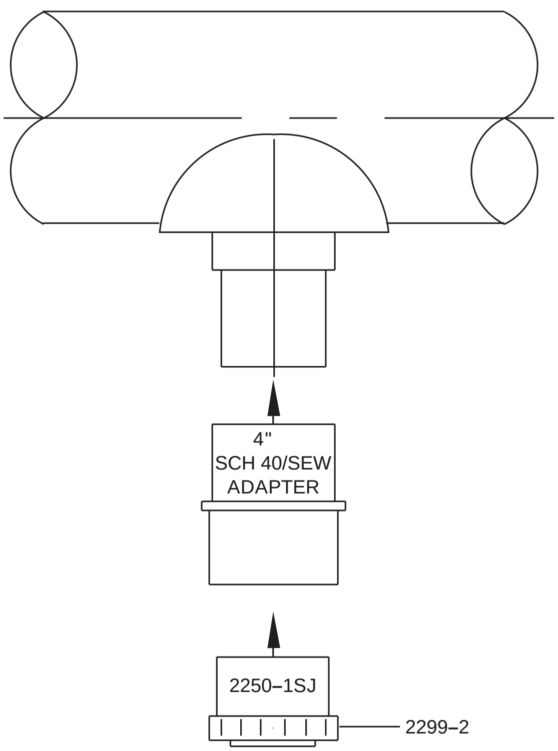
REPAIR

STEP No. (1)

1) CUT THE SPIGOT & RETAINING RING END OF THE FIXED JOINT OFF PERPENDICULAR TO THE CONNECTION AT A DISTANCE OF 1/2" (12 mm) FROM THE REAR END OF THE SOCKET FITTING.

2) DEBUR THE CUT PIPE END.





REPAIR

STEP No. (2)

1) OBTAIN THE REQUIRED QUANTITIES OF 4" SCH 40 TO SEWER SIZE ADAPTERS AND SPIGOT & RETAINING RING ASSEMBLIES (2250–1SJ & 2299–2) FROM THE SUPPLIER.

2) CLEAN & PRIME THE CUT PIPE END AND THE SEWER SIZE SOCKET END OF THE SCH 40/SEWER SIZE ADAPTER.

3) SOLVENT CEMENT THE SCH 40/SEWER SIZE ADAPTER TO THE CUT PIPE END.

4) CLEAN & PRIME THE OUTSIDE FACE OF THE SPIGOT & RETAINING RING AND THE SCH 40 SOCKET END OF THE SCH 40/SEWER SIZE ADAPTER.

5) CAREFULLY SOLVENT CEMENT THE SPIGOT & RETAINING RING END OF THE FIXED JOINT INTO THE SCH 40 SOCKET END OF THE SCH 40/SEWER SIZE ADAPTER. THE RETAINING RING MUST BE FREE TO ROTATE. DO NOT ALLOW EXCESS GLUE TO COME IN CONTACT WITH THE RETAINING RING.

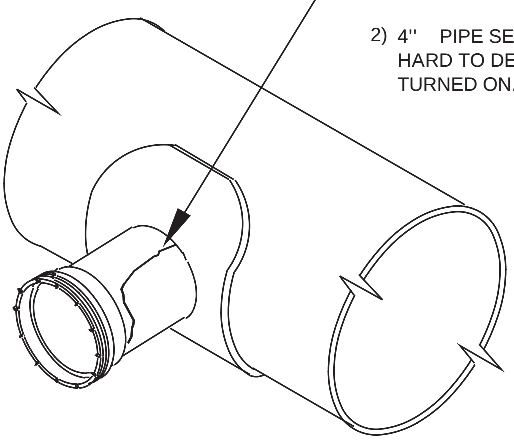
SAN B

MANIFOLD REPAIR – SPIGOT & RETAINING RING
AIR DISTRIBUTOR CONNECTION ON A 3-PIECE FABRICATED SADDLE ASSEMBLY

PROBLEM

1) 4'' PIPE SECTION VISIBLY BROKEN OFF.

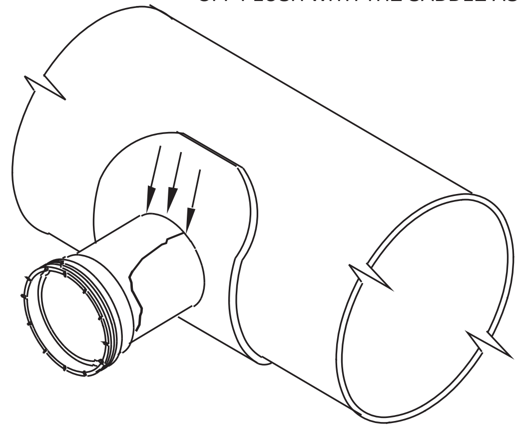
2) 4'' PIPE SECTION CRACKED. MAY BE HARD TO DETECT UNTIL AIR IS TURNED ON.



REPAIR

STEP No. (1)

USE A RECIPROCATING TYPE SAW (SAWZALL) AND CUT THE PIPE SECTION OFF FLUSH WITH THE SADDLE AS SHOWN.

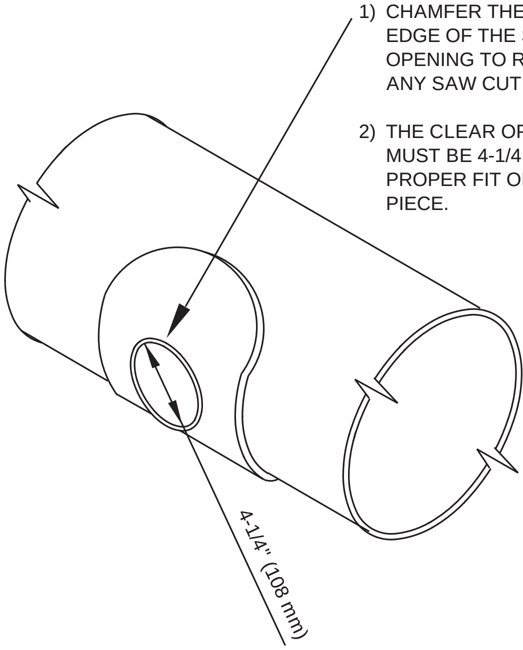


REPAIR

STEP No. (2)

1) CHAMFER THE INSIDE EDGE OF THE SADDLE OPENING TO REMOVE ANY SAW CUT PROJECTIONS.

2) THE CLEAR OPENING DIAMETER MUST BE 4-1/4" (108 mm) FOR PROPER FIT OF NEW SADDLE PIECE.



REPAIR

STEP No. (3)

1) DETERMINE THE MANIFOLD PIPE (O.D.) AND QUANTITY OF BROKEN OR CRACKED PIPE CONNECTIONS.

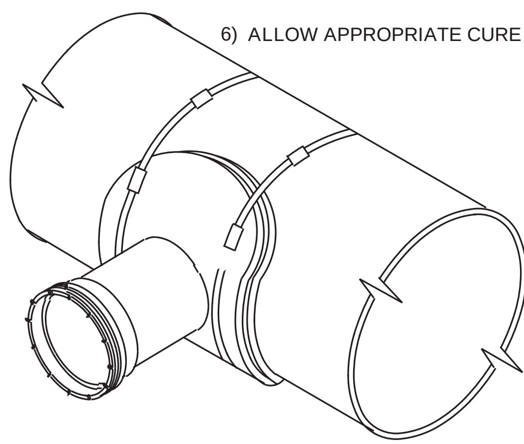
2) ORDER THE APPROPRIATE SADDLE REPAIR ASSEMBLY FROM THE SUPPLIER.

3) CLEAN AND PRIME SURFACES PRIOR TO CEMENTING.

4) SOLVENT CEMENT. THE NEW SADDLE ASSEMBLY DIRECTLY OVER THE EXISTING SADDLE USING A HEAVY BODY SOLVENT CEMENT. MAKE SURE NEW SADDLE IS LEVEL TO PROPERLY ALIGN WITH AIR DISTRIBUTOR.

5) SECURE SADDLE ASSEMBLY TO MANIFOLD WITH (SS) STRAP CLAMPS PROVIDED WITH REPAIR KIT.

6) ALLOW APPROPRIATE CURE TIME.

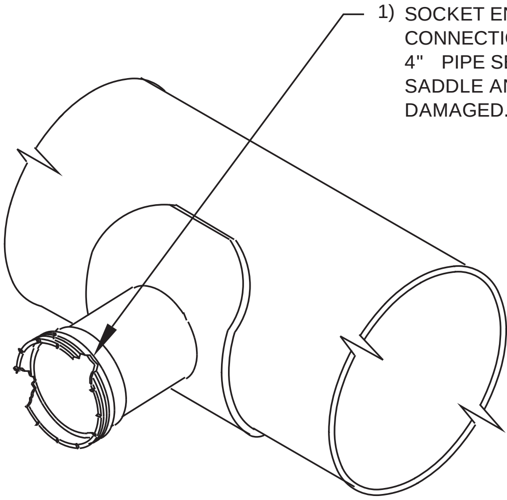


SAN C

MANIFOLD REPAIR – AIR DISTRIBUTOR CONNECTION SADDLE REPLACEMENT ON A 1–PIECE MOLDED SADDLE ASSEMBLY

PROBLEM

1) SOCKET END OF FIXED JOINT CONNECTION IS DAMAGED. 4" PIPE SECTION BETWEEN SADDLE AND JOINT IS NOT DAMAGED.

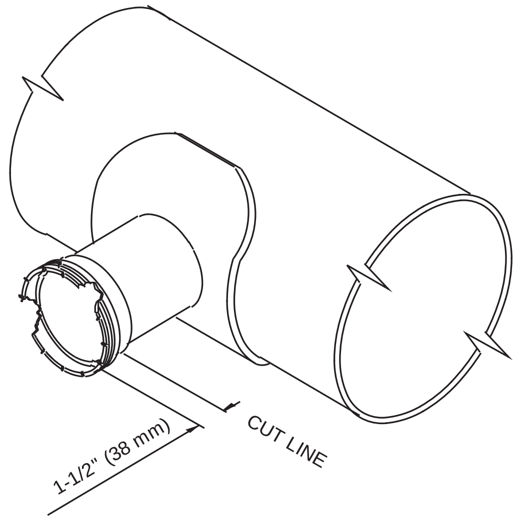


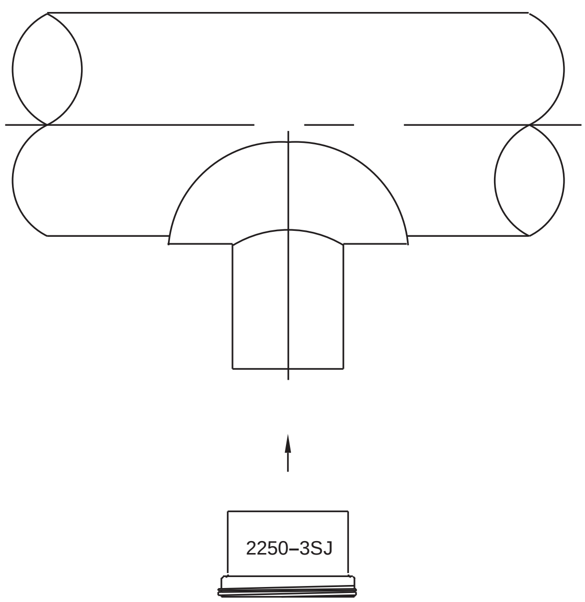
REPAIR

STEP No. (1)

1) CUT THE SOCKET END OF THE FIXED JOINT OFF PERPENDICULAR TO THE CONNECTION AT A DISTANCE OF 1-1/2" (38 mm) FROM THE FACE OF THE SOCKET END.

2) DEBUR THE CUT PIPE END.





REPAIR

STEP No. (2)

1) OBTAIN THE REQUIRED QUANTITY OF FIXED JOINT SOCKETS (2250-3SJ) FROM THE SUPPLIER.

2) CLEAN & PRIME THE CUT PIPE END AND THE INSIDE OF THE SOCKET END FITTING.

3) SOLVENT CEMENT THE SOCKET END TO THE CUT PIPE END.

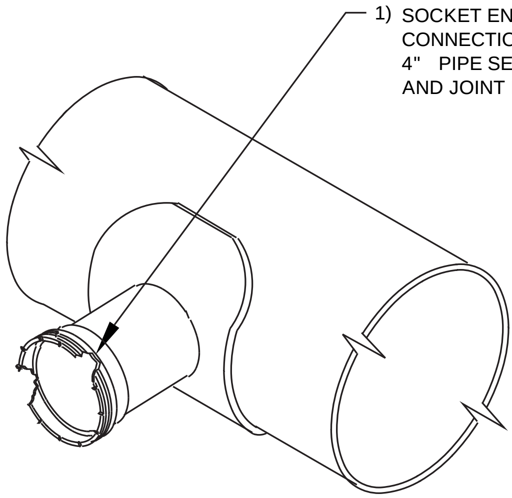
4) ALLOW ADEQUATE CURE TIME.

SAN D

MANIFOLD REPAIR – SOCKET AIR DISTRIBUTOR CONNECTION ON A 1–PIECE MOLDED SADDLE ASSEMBLY, 6" – 10" (150–250 mm) MANIFOLDS

PROBLEM

1) SOCKET END OF FIXED JOINT CONNECTION IS DAMAGED. 4" PIPE SECTION BETWEEN SADDLE AND JOINT IS NOT DAMAGED.

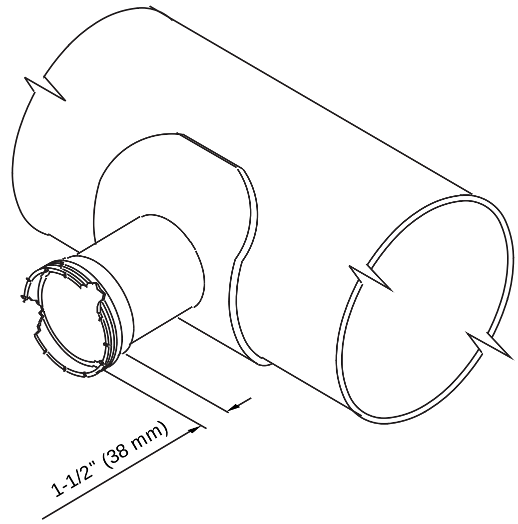


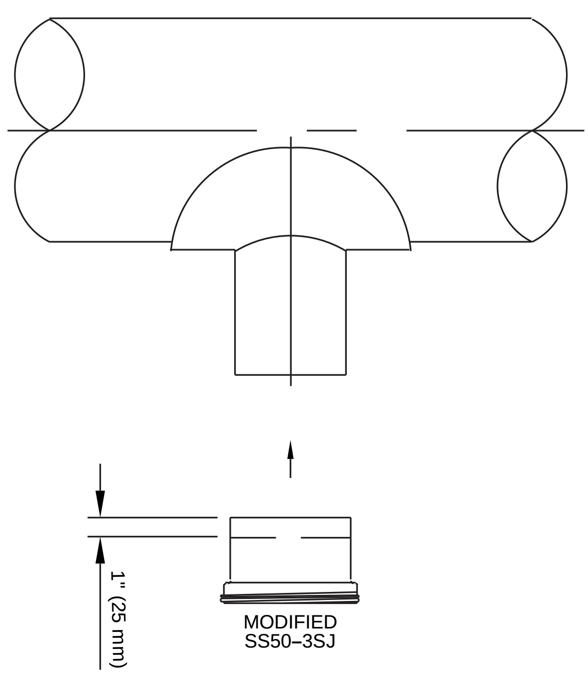
REPAIR

STEP No. (1)

1) CUT THE SOCKET END OF THE FIXED JOINT OFF PERPENDICULAR TO THE CONNECTION AT A DISTANCE OF 1-1/2" (38 mm) FROM THE FACE OF THE SOCKET END.

2) DEBUR THE CUT PIPE END.





REPAIR

STEP No. (2)

1) OBTAIN THE REQUIRED QUANTITY OF MODIFIED FIXED JOINT SOCKETS (2250–3SJ) FROM THE SUPPLIER. (1" OF SOCKET REMOVED)

2) CLEAN & PRIME THE CUT PIPE END AND THE INSIDE OF THE SOCKET END FITTING.

3) SOLVENT CEMENT THE SOCKET END TO THE CUT PIPE END.

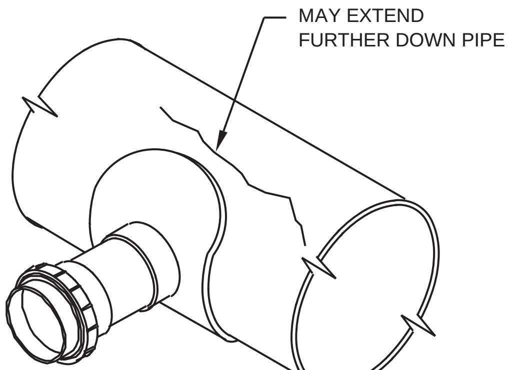
4) ALLOW ADEQUATE CURE TIME.

SAN E

MANIFOLD REPAIR – SOCKET AIR DISTRIBUTOR CONNECTION ON A 1–PIECE MOLDED SADDLE ASSEMBLY, 12" (300 mm) MANIFOLDS

PROBLEM

CRACKED MANIFOLD PIPE SECTION.

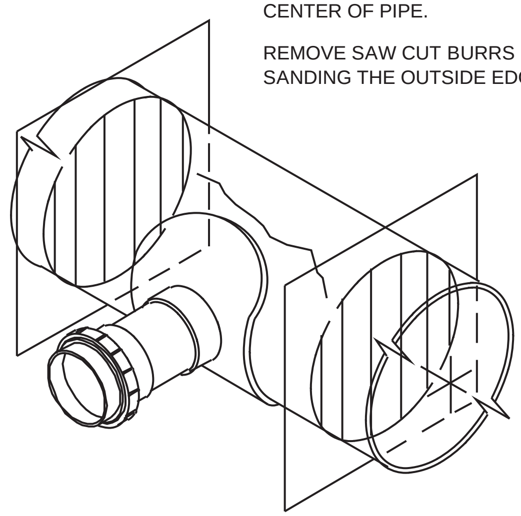


REPAIR

STEP No. (1)

CUT THE BROKEN PIPE SECTION OUT OF THE MANIFOLD BETWEEN SADDLES. THE CUT MUST BE PERPENDICULAR TO THE CENTER OF PIPE.

REMOVE SAW CUT BURRS BY FILING OR SANDING THE OUTSIDE EDGE OF THE PIPE.



REPAIR

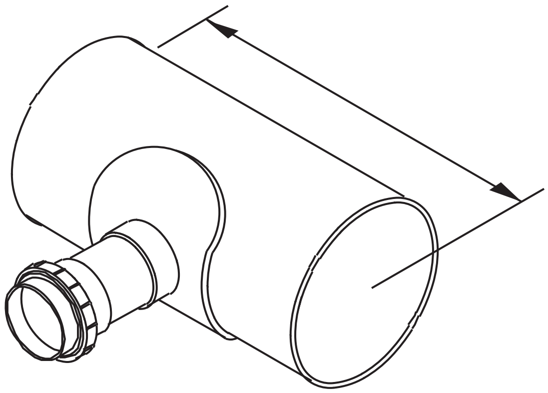
STEP No. (2)

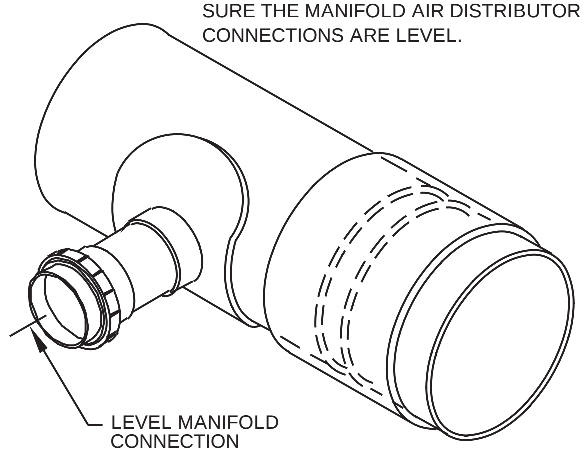
1) DETERMINE AND ORDER THE REQUIRED REPAIR PARTS FROM THE SUPPLIER.
2) CUT A LENGTH OF REPAIR PIPE OF THE CORRECT DIAMETER AND QUANTITY OF PIPE SADDLES.
3) THE ENDS MUST BE CUT SQUARE.
4) DE-BURR THE ENDS OF THE PIPE.

REPAIR

STEP No. (3)

1) OBTAIN THE PROPER SIZE AND TYPE OF PVC COUPLINGS.
2) SOLVENT CEMENT THE REPAIR SECTION TO THE COUPLINGS AS REQUIRED.
   USE A HEAVY BODY SOLVENT CEMENT AND COMPATIBLE PRIMER TO MAKE GLUE JOINTS.
3) SOLVENT CEMENT THE REPAIR SECTION TO THE ORIGINAL MANIFOLD SECTIONS. MAKE SURE THE MANIFOLD AIR DISTRIBUTOR CONNECTIONS ARE LEVEL.





SAN F

MANIFOLD REPAIR – CRACKED MANIFOLD PIPE SECTION

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PROBLEM

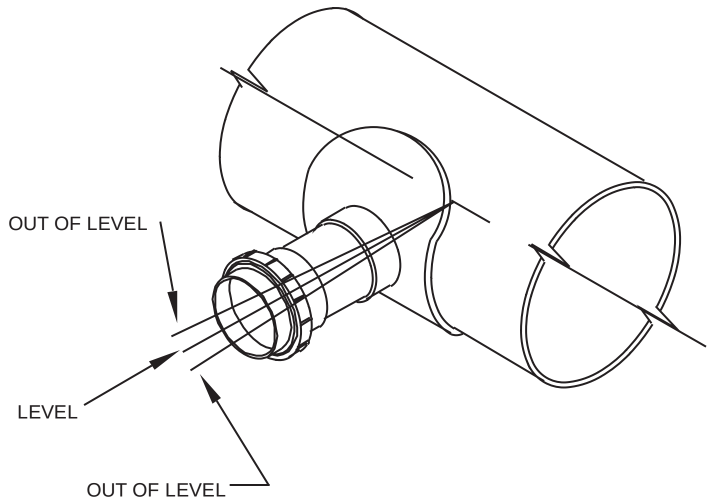
1) IN-LINE MANIFOLD AIR DISTRIBUTOR CONNECTION INSTALLED OUT OF HORIZONTAL LEVEL CAUSING AIR DISTRIBUTOR TO BE OUT OF LEVEL. (SHOWN ON SKETCH)

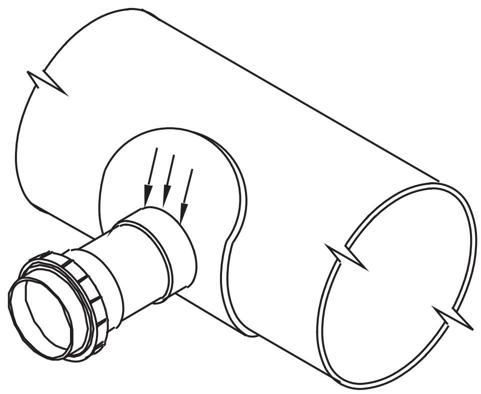
2) RAISED MANIFOLD AIR DISTRIBUTOR CONNECTION INSTALLED OUT OF VERTICAL PLUMB CAUSING AIR DISTRIBUTOR TO BE OUT OF LEVEL.

REPAIR

STEP No. (1)

USE A RECIPROCATING TYPE SAW (SAWZALL) AND CUT THE SPIGOT SECTION OFF FLUSH WITH THE SADDLE AS SHOWN.





REPAIR

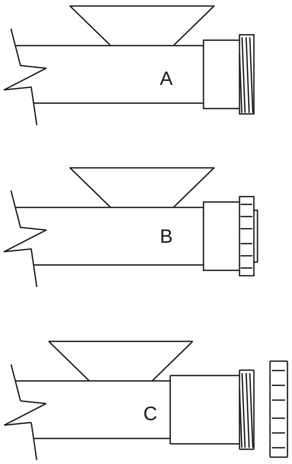
STEP No. (2)

1) REFER TO DRAWING SAN A IF THE AIR DISTRIBUTOR CONNECTION IS A FABRICATED 3-PIECE SADDLE WITH A SPIGOT AND RETAINING RING.

2) REFER TO DRAWING SAN C IF THE AIR DISTRIBUTOR CONNECTION IS A MOLDED 1-PIECE SADDLE WITH A SOCKET FITTING.

SAN G

MANIFOLD REPAIR - MISALIGNED AIR DISTRIBUTOR CONNECTION



PROBLEM

DAMAGED FIXED JOINT OR EXPANSION JOINT

A) FIXED JOINT SOCKET 2250-3SJ

B) FIXED JOINT SPIGOT 2250-1SJ
FIXED JOINT RETAINING RING 2299-2

C) EXPANSION JOINT BARREL 2306-1XS
EXPANSION JOINT RETAINING RING 2306-2XR

* 2250-3 IS A SPLINED SOCKET
* 2250-1 IS A NOTCHED SPIGOT

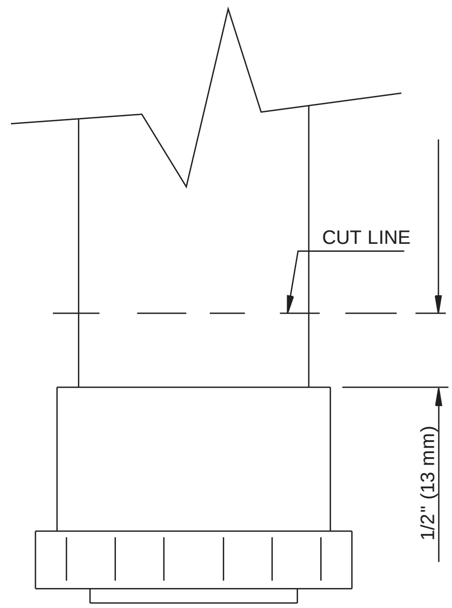
REPAIR

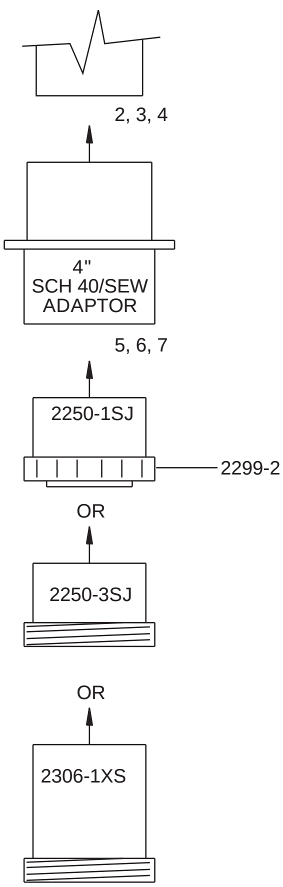
STEP No. (1)

REMOVE DAMAGED JOINT END BY CUTTING THE ATTACHED PIPE SECTION AT A DISTANCE OF (1/2") FROM THE END OF THE FITTING.

CARE SHOULD BE TAKEN TO MAKE CUT AS SQUARE AS POSSIBLE.

DE-BURR PIPE END.





REPAIR

STEP No. (2)

1) OBTAIN THE REQUIRED QUANTITY OF REPAIR PARTS FROM SUPPLIER.
2) CLEAN AND PRIME CUT PIPE END.
3) CLEAN AND PRIME THE INSIDE OF THE SMALL OR SEWER SIZE END OF A PVC SCH 40/SEWER ADAPTOR.
4) SOLVENT CEMENT THE PIPE ADAPTOR TO THE PIPE END.
5) CLEAN AND PRIME THE OPPOSITE END OF THE SCH 40/SEWER ADAPTOR.
6) CLEAN AND PRIME THE OUTSIDE FACE OF THE REQUIRED JOINT REPAIR END.
7) SOLVENT CEMENT THE JOINT END INTO SCH 40/SEWER PIPE ADAPTOR.

NOTE:
IF A SPIGOT AND RETAINING RING IS USED. DO NOT PUSH THE SPIGOT SO FAR INTO THE PIPE ADAPTOR WHERE FREE ROTATION OF THE RETAINING RING IS PROHIBITED. THE RETAINING RING MUST BE FREE TO ROTATE.

SAN H

AIR DISTRIBUTOR REPAIR - DAMAGED FIXED JOINT SPIGOT END, SOCKET END OR EXPANSION JOINT SOCKET END

PROBLEM

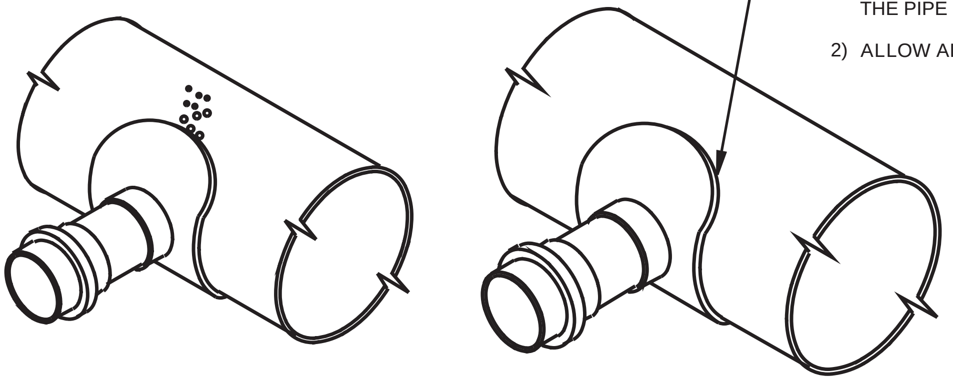
PIN HOLE LEAK AROUND THE EDGE OF THE AIR DISTRIBUTOR PIPE CONNECTION SADDLE AS EVIDENT BY AIR RELEASE AT START-UP

REPAIR

STEP No. (1)

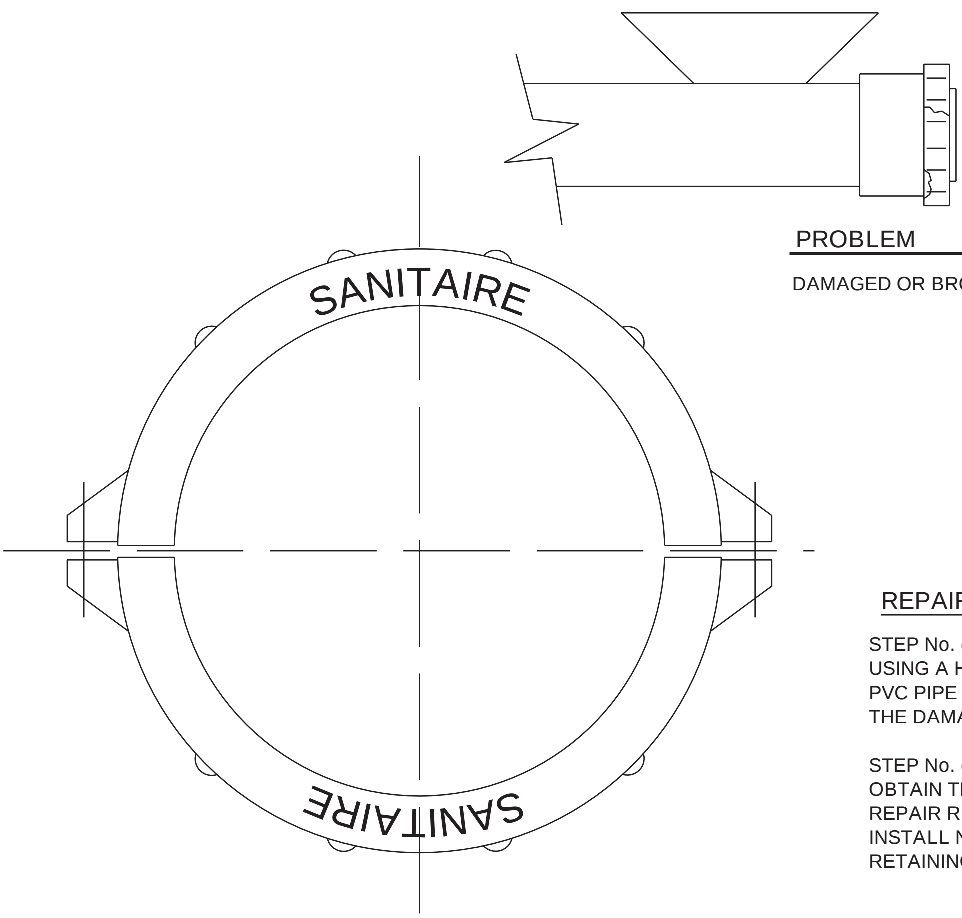
1) APPLY A BEAD OF HEAVY BODY SOLVENT CEMENT AROUND THE EDGE OF THE PIPE SADDLE.

2) ALLOW ADEQUATE CURE TIME.



SAN I

MANIFOLD REPAIR - PIN HOLE LEAK AROUND THE EDGE OF THE AIR DISTRIBUTOR SADDLE CONNECTION



PROBLEM

DAMAGED OR BROKEN RETAINING RING(2299-2)

REPAIR

STEP No. (1)
USING A HAND HELD HACKSAW OR PVC PIPE SAW CAREFULLY CUT-OFF THE DAMAGED RETAINING RING.

STEP No. (2)
OBTAIN THE REQUIRED QUANTITY OF REPAIR RINGS FROM THE SUPPLIER. INSTALL NEW SPLIT FIXED JOINT RETAINING RING No.2299-REP

SAN J

AIR DISTRIBUTOR REPAIR - DAMAGED FIXED JOINT RETAINING RING

PROBLEMS

(A) CRACKED AIR DISTRIBUTOR PIPE.

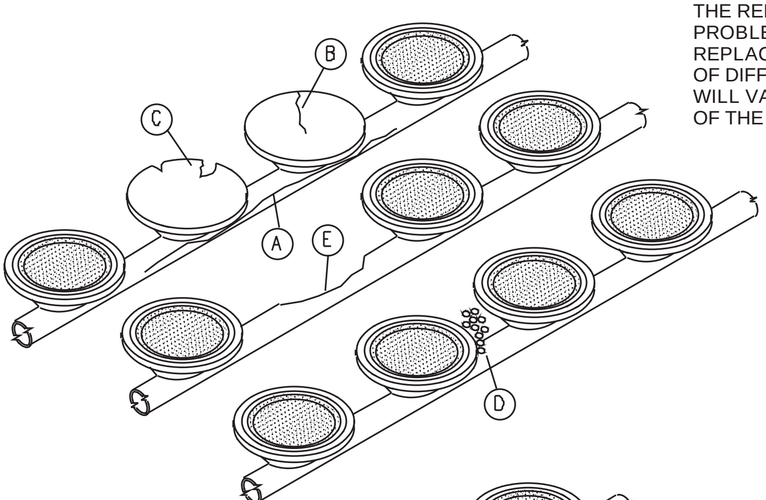
(B) CRACKED DIFFUSER HOLDER.

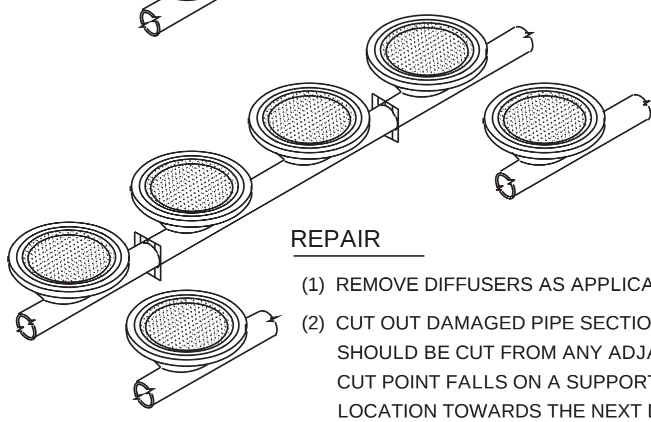
(C) CHIPPED DIFFUSER HOLDER.

(D) OUT OF ROUND DIFFUSER HOLDER (RARE) WILL NOT SEAL.

(E) DIFFUSER HOLDER BROKEN OFF.

THE REPAIR OF THE ABOVE LISTED PROBLEMS INVOLVES CUTTING OUT AND REPLACING A PIPE SECTION. THE NUMBER OF DIFFUSERS THAT REQUIRE REMOVAL WILL VARY DEPENDING ON THE EXTENT OF THE DAMAGE.

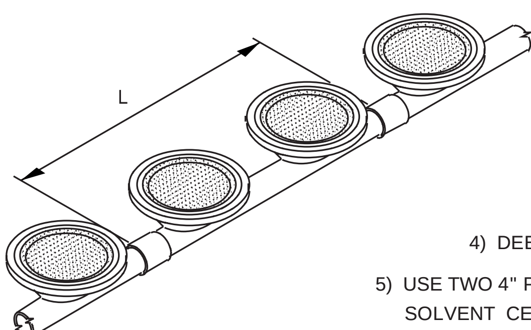




REPAIR

(1) REMOVE DIFFUSERS AS APPLICABLE FROM DAMAGED PIPE SECTION.

(2) CUT OUT DAMAGED PIPE SECTION. THE MINIMUM DISTANCE THE PIPE SHOULD BE CUT FROM ANY ADJACENT DIFFUSER IS 6" (150 mm). IF THE CUT POINT FALLS ON A SUPPORT LOCATION MOVE OFF THE SUPPORT LOCATION TOWARDS THE NEXT DIFFUSER IF SPACING ALLOWS OR MOVE DOWN TO SPACE BETWEEN NEXT DIFFUSER FOR TIGHTLY SPACED DIFFUSERS.



3) FROM A SPARE DISTRIBUTOR SECTION OR REPAIR MATERIALS SENT BY THE SUPPLIER CUT A SECTION TO THE REQUIRED LENGTH WITH THE APPROPRIATE NUMBER OF DIFFUSERS AT THE CORRECT DIFFUSER SPACING.

4) DEBUR, CLEAN AND PRIME ALL CUT ENDS.

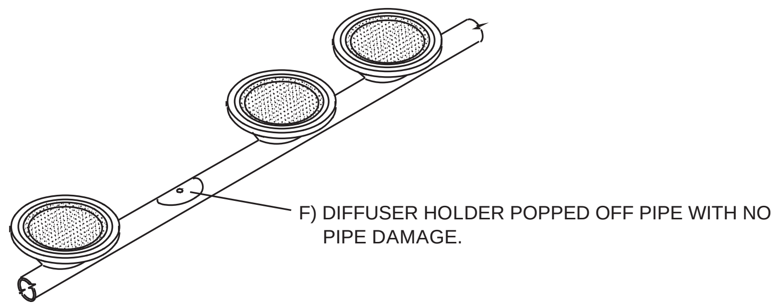
5) USE TWO 4" PVC SEWER SIZE COUPLINGS AND SOLVENT CEMENT THE REPAIR PIPE SECTION INTO PLACE.

6) ALL DIFFUSERS MUST BE KEPT ON THE SAME PLANE.

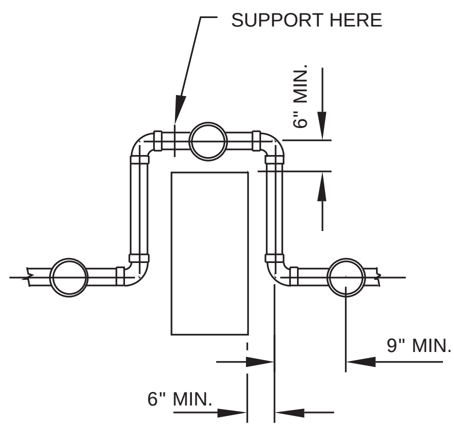
7) ALLOW APPROPRIATE CURE TIME. INSTALL THE DIFFUSERS, TIGHTEN ANY SUPPORTS THAT MAY HAVE BEEN LOOSENED, TEST AND PUT BACK IN SERVICE.

SAN K

AIR DISTRIBUTOR REPAIR - DAMAGED DIFFUSER HOLDER OR PIPE AND OBSTACLE, PIPE RE-ROUTING REQUIREMENTS



1) CLEAN HOLDER AREA OF ANY OLD SOLVENT CEMENT RESIDUE.
2) PRIME HOLDER AREA AND BOTTOM OF DIFFUSER HOLDER.
3) USE A HEAVY BODY SOLVENT CEMENT AND ATTACH HOLDER ON PIPE.
4) ALLOW APPROPRIATE CURE TIME.



PROBLEM

G) AIR DISTRIBUTOR INSTALLATION REQUIRES ROUTING AROUND AN OBSTACLE

REPAIR

USE 90° SEWER SIZE PVC SOCKET ELBOWS, SANITAIRE P.N. 4SEW-EL9 AND 4.215"O.D. SEWER PIPE TO MAKE NECESSARY MODIFICATIONS.

MAKE SURE THE OFFSET AIR DISTRIBUTOR RUN IS ADEQUATELY SUPPORTED.

SAN L

AIR DISTRIBUTOR REPAIR - DAMAGED DIFFUSER HOLDER OR PIPE AND OBSTACLE, PIPE RE-ROUTING REQUIREMENTS (Continued)

Sanitaire Partial Installation List

Job #	Plant	Location	Equipment	MGD	Quantity	Start	Contact	Enginee
07-6799s	Lakeland - West Lakeland WRF	FL	9" Membrane	1	11,596			Black and Veatch
08-6889s	Arlington East WRF	FL	9" Membrane		23,408			Hazen and Sawyer
05-5925s	Bonita Springs - WWTP	FL	9" Membrane		1,800			CH2M Hill
98-4057s	Bradenton	FL	9" Membrane		2,016			Smith and Gillespie, Inc
03-5533s	Broward County - N R WWTP	FL	9" Membrane		13,320			Hazen and Sawyer
98-3947s	Callaway Wwtp	FL	9" Membrane		8,080			Baskerville-Donovan, Inc
93-2893s	Cocoa Beach WWTP	FL	9" Membrane		-		Cocoa Beach, FL	Quentin L. Hampton Associates
02-5031s	Collier County - S C W R F	FL	9" Membrane		9,144			CH2M Hill
01-4802s	Collier County - S C W R F	FL	9" Membrane		3,132	2002		CH2M Hill
02-5003s	Collier County - S C W R F	FL	9" Membrane		165	2002		CH2M Hill
02-5314s	Collier County North WRF - Naples	FL	9" Membrane	30.6	5,888			Hazen and Sawyer
99-4416s	Collier County- North Wwtp	FL	9" Membrane		4,412			Hazen and Sawyer
99-4116s	Collier Cty - North WWTP	FL	9" Membrane		-			Hazen and Sawyer
04-5693s	Coral Springs Inprovement District -	FL	9" Membrane		2,784			CH2M Hill
01-4941s	Coral Springs WWTP	FL	9" Membrane		672	2002		Gee and Jensen
09-7065s	Coral Springs WWTP	FL	9" Membrane		1,680			CH2M HILL
08-7009s	Crestview - Bob Sikes WWTP	FL	9" Membrane	10	840			Constantine Engineering
90-2043s	Davco - Lynn Haven	FL	9" Membrane		800		Lynnn Haven WWTP	US Filter
06-6424s	Davco - Winter Springs	FL	9" Membrane		45			Davco
06-6355s	Davco - Winter Springs	FL	9" Membrane		45			Davco
89-1952s	Dunedin WWTP	FL	9" Membrane		2,688		Dunedin, FL - City of	Howard Needles Tammen ...
98-4131s	Fort Lauderdale Sludge Holding Fac	FL	9" Membrane		520			CH2M Hill
97-3801s	Glendale Wwtp	FL	9" Membrane		2,064			Chastain Skillman
07-6685s	Indian River County West Reg WWTP	FL	9" Membrane		6,616			Post Buckley Schuh and Jernigan
98-4176s	Indian River-South Cty Wwtp	FL	9" Membrane		192			CDM
06-6300s	J E A - Southwest Modifications	FL	9" Membrane		5,278			Boyle Engineering
00-4499s	Jacksonville - Arlington East	FL	9" Membrane		-			Pittman Hartenstein and Assoc Inc
03-5519s	Jacksonville - Buckman Street WWTP	FL	9" Membrane		2,336			JEA

Job #	Plan	Locatio	Equipmen	MGD	Quantity	Start	Contac	Engineer
01-4810s	Jacksonville - Southwest WRP	FL	9" Membrane		5,190	2002		Black and Veatch
02-5054s	Jacksonville J E A - WWTP	FL	9" Membrane		9,520			Black and Veatch
00-4484s	Jacksonville, Sw Wrf	FL	9" Membrane		882			Fluor Daniels
09-7212s	Key West	FL	9" Membrane		5,180			CDM
93-2674s	Kissimmee- Camalot Wwtp	FL	9" Membrane		1,984		Kissimmee, FL	Professional Engineering
02-5266s	Largo WWTP	FL	9" Membrane		6,394			Parsons Engineering Science
96-3587s	Largo WWTP	FL	9" Membrane		3,222		Clearwater, FL	Quentin L. Hampton Associates
04-5905s	Loxahatchee W W T P	FL	9" Membrane		7,800			Hazen and Sawyer
06-6303s	Marco Island	FL	9" Membrane	1	2,746			CDM
08-6903s	Marco Island WWTP	FL	9" Membrane		2,964			CDM
08-7001s	Marshall St.	FL	9" Membrane		6,660			Malcolm Pirnie, Inc.
08-6928s	Meadowcrest	FL	9" Membrane	2	2,410			McKim and Creed
04-5906s	Nassau County, Fl WWTP - Yulee	FL	9" Membrane		2,169			Jacksonville Electric Auth
05-6095s	Navarre Beach WWTP	FL	9" Membrane		724			CH2M Hill
08-6839s	North Port	FL	9" Membrane		3,183			Brown and Caldwell
12-7726s	Orange Cnty Nwwrf	FL	9" Membrane		12,463			Black and Veatch
00-4596s	Orange County Utilities - Sand Lake Road	FL	9" Membrane		1,675			CDM
07-6642s	Orange Tree Utility Naples	FL	9" Membrane		448			A.M. Engineering
96-3548s	Palm Beach Gardens-Pga WWTP	FL	9" Membrane		8,946		PGA Wastewater Treatment	CH2M Hill
98-3958s	Panama City Beach	FL	9" Membrane		1,536			Baskerville-Donovan, Inc
00-4454s	Panama City Beach	FL	9" Membrane		3,064			Baskerville-Donovan, Inc
08-6845s	Pasco County - Shady Hills WWTP	FL	9" Membrane	20	1,820			King Engineering
07-6790s	Pasco County - Shady Hills WWTP	FL	9" Membrane	20	1,820			King Engineering
93-2907s	Pembroke Pines WWTP	FL	9" Membrane		2,694		City of Pembroke Pine	US Filter
93-2761s	Pembroke Pines Wwtp	FL	9" Membrane		1,322		City of Pembroke Pine	Greeley and Hansen
97-3895s	Port Orange WWTP	FL	9" Membrane		3,012			Quentin L. Hampton Associates
02-5219s	Port Orange WWTP	FL	9" Membrane		5,548			Quentin L. Hampton Associates
04-5830s	Port St. Lucie - Glades WWTP	FL	9" Membrane	6	6,750			Reese Macon and Associates
07-6570s	Port St. Lucie - Glades WWTP	FL	9" Membrane		5,300			RMA Engineering Company
90-2184s	Reedy Creek WWTP	FL	9" Membrane		24,487		Reedy Creek	CH2M Hill

xylem
Let's Solve Water

SANITAIRE

Job #	Plan	Locatio	Equipmen	MGD	Quantity	Start	Contac	Engineer
92-2512s	Sanford WWTP	FL	9" Membrane		2,592		Sanford	Conklin, Porter and Holmes
02-5106s	Sarasota - Bee Ridge WWTP	FL	9" Membrane		10,810			MWH
07-6686s	Seminole County - Yankee Lake WWTP	FL	9" Membrane		3,440			Boyle Engineering
91-2280s	Siesta Key Utility Authority	FL	9" Membrane		1,372		Siesta Key Utility	A.M. Engineering
07-6600s	St. Cloud WWTP	FL	9" Membrane		5,520			Jones Edmunds
07-6596s	St. Petersburg - N W W R F	FL	9" Membrane		4,706			Malcolm Pirnie, Inc.
11-7592s	St. Petersburg - S W W R F	FL	9" Membrane	20	6,504			Boyle Engineering
06-6279s	Stuart	FL	9" Membrane		898			Brown and Caldwell
06-6281s	Stuart	FL	9" Membrane		898			Brown and Caldwell
05-6183s	Stuart WWTP	FL	9" Membrane	2	2,336			Brown and Caldwell
11-7649s	T.p. Smith WRF	FL	9" Membrane		20,118			Hazen and Sawyer
98-3937	Talquin Electric - Killearn WWTP	FL	9" Membrane		1,012			Southern Eng.
93-2731s	Tamp- Hookers Point WWTP	FL	9" Membrane		21,993		Tampa	Greeley and Hansen
06-6312s	West Melbourne	FL	9" Membrane	3.5	3,894			CH2M HILL
	72 Installations				337,527			

SANITAIRE MEMBRANE DISC INSTALLATION
REFERENCE LIST

1. LEWISVILLE, TX
   WASTEWATER TREATMENT PLANT
   897 TREATMENT PLANT ROAD
   LEWISVILLE, TX 75057
   MR. DOUG LIPSCOMB, OPERATIONS SUPERVISOR
   PHONE: 972-219-3545
   FAX: 972 219-3506

2. OSHKOSH, WI
   WASTEWATER TREATMENT PLANT
   233 CAMPBELL ROAD
   OSHKOSH, WI 54901-3488
   MR. TOM KRUSICK
   PHONE: 920 232-5365 (5360)
   FAX: 920-232-5366

3. GRAND HAVEN, MI
   WASTEWATER TREATMENT PLANT
   1525 SO. WASHINGTON ST
   GRAND HAVEN, MI 49417
   DAVID KROHN, ENVIRONMENTAL COMPLIANCE
   PHONE: 616 847-3485
   FAX: 616-847-4880

4. BATTLE CREEK, MI
   WASTEWATER TREATMENT PLANT
   2000 WEST RIVER
   BATTLE CREEK, MI 49015
   MR. LARRY DELONG
   PHONE: 616 966-3513
   FAX: 616-965-3290

5. GOODYEAR, AZ
   WASTEWATER TREATMENT PLANT
   200 S. CALLE DEL PUEBLO
   GOODYEAR, AZ 85338
   MR. BARRY HESS
   PHONE: 623-932-3010
   FAX: 623-932-2171

6. LA JUNTA, CO

WASTEWATER TREATMENT PLANT
P. O. BOX 469
LA JUNTA, CO 81050
MR. GLENN PLEASANTS
PHONE: 719 384-3633
FAX: 719-384-8412

7. NORTH EAST, PA
WASTEWATER TREATMENT PLANT
58 E. MAIN ST
NORTH EAST, PA 16428
MR. CRAIG NIGLEMAN
PHONE: 814-725-8037
FAX: 814-725-4996

8. WINOOSKI, VT
WASTEWATER TREATMENT PLANT
27 W. ALLEN ST
WINOOSKI, VT 05404
MR. TIM GROVER
PHONE: 802-655-6421
FAX: 802-655-6421

9. EAGLE RIVER, AK
WASTEWATER TREATMENT PLANT
1725 – 8 AVENUE SOUTH
EAGLE RIVER, AK 99577
MR. MIKE RUTHERFORD
PHONE: 907-694-9684
FAX: 907-694-8419

10. NAPERVILLE, IL
WASTEWATER TREATMENT PLANT
3712 PLAINFIELD/NAPERVILLE ROAD
NAPERVILLE, IL 60566-7020
MR. TIMOTHY CARDELLA
PHONE: 630-420-6686
FAX: 630-420-4118

TETRA TECH, INC.

ATTACHMENT D
SANITAIRE MEMBRANE PANEL/DISC PROPOSAL
(OPTION 5)

SANITAIRE
a xylem brand

Diffused Aeration Equipment

for

City of Tampa WWTP

Fine Pore Aeration - Gold Series

Prepared For:

Tetra Tech RTW

1576 Sherman St.
Suite 100
Denver, CO 80203

Represented By:
Moss-Kelley Inc.
725 Primera Blvd - Suite 155
Lake Mary, FL 32746
407 805-0063

Sanitaire #s23698-13
February 12, 2013
im K:\s23698-13\2013.1.21 AB Set-Up (Gold Series & SS-II Mix).aer

Sanitaire Aeration Design Inputs for: City of Tampa WWTP, Sanitaire #s23698-13

Tank Geometry

4 Trains each Consisting of:

Parameter	Units	Pass 1
Parallel Reactors		1
Pass Process		Aerobic
SWD	ft	17.0
Submergence	ft	15.9
Volume	ft³	286,518.6
Reactor Geometry:		Rect
Length	ft	318.0
Width	ft	53.0

Oxygen/Air Distribution

	Zone	1	2	3	4	5	6
	Pass	1	1	1	1	1	1
Default		32.0%	28.0%	20.0%	10.0%	6.0%	4.0%

Oxygenation

Parameter	Units	Current Avg. Day	Current Max Day	Future Avg. Day	Future Max Day
No. Trains Operating		4	4	4	4
Oxygen Requirement	lb/day	***50,000.0-A***	***90,000.0-A***	***70,000.0-A***	***126,000.0-A***

Standard Oxygen Correction Factor Parameters

Parameter	Units	Current Avg. Day	Current Max Day	Future Avg. Day	Future Max Day
Alpha		***0.55***	***0.55***	***0.55***	***0.55***
Beta		***0.95***	***0.95***	***0.95***	***0.95***
Theta		1.024	1.024	1.024	1.024
Dissolved Oxygen	mg/l	***2***	***1***	***2***	***1***
Site Elevation	FASL	7	7	7	7
Ambient Pressure	PSIA	14.70	14.70	14.70	14.70
Water Temperature	°C	***30***	***30***	***30***	***30***

Notes:

Bold, Italicized text indicate assumptions made by Sanitaire

A - Indicates Actual (AOR) Requirement.

S - Indicates Standard Condition (SOR) Oxygen requirement.

If the AOR/SOR parameter is not given, then its value will be evaluated later if suitable alpha, beta, D.O., theta, pressure, and temperature data is supplied.

Round tanks are evaluated as rectangular tanks diameter equal to length and equal surface area.

Annular tanks are evaluated as rectangular tanks of width equal to the annular width and equal surface area.

Sanitaire Project Name: City of Tampa WWTP
Sanitaire Project #s23698-13
Design Summary

		Point & O2			
	Units	Current Avg. Day Default	Current Max Day Default	Future Avg. Day Default	Future Max Day Default
No. Trains in Operation		4	4	4	4
No. Grids in Operation		24	24	24	24
No. Operating Diffusers		5,852	5,852	5,852	5,852
Diffuser Area	ft²	14,311	14,311	14,311	14,311
SOR	lb/day	128,323	187,874	169,992	258,975
SOTE	%	37.2	35.4	35.9	33.6
Total Air Rate	scfm	13,768	21,182	18,880	30,798
Min.Diffuser Air Rate	scfm/diff.	1.34	1.34	1.34	1.35
Max. Diffuser Air Rate	scfm/diff.	1.34	1.46	1.34	2.15
Static Pressure	psig	6.91	6.91	6.91	6.91
Diffuser DWP @ Min Air	psig	0.51	0.51	0.51	0.51
Diffuser DWP @ Max Air	psig	0.51	0.52	0.51	0.57
Pressure @ Top of Dropleg	psig	7.56	7.6	7.56	7.86
Est. Blower Efficiency		70%	70%	70%	70%
Est. Motor Efficiency		90%	90%	90%	90%
Shaft Power	Bhp	572.9	885.2	785.6	1,324
Est. Motor Electrical Load	kW	474.9	733.7	651.2	1,097
Est. Standard Aeration Efficiency	#SOR/BHP-hr	9.33	8.84	9.02	8.15

Notes:

(1) Design air is the maximum of process air or mixing air

(2) Delivered oxygen based on design air

(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss

(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.

(5) Diffuser Air Flow based on Active Valve Modulation

(6) Blower Pressure Capability also requires consideration of:

A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.

B. Potential for increased headloss resulting from diffuser fouling and/or aging. Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other

technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.

C. Increased diffuser submergence during Peak Flow conditions.

(7) Air Flow defined at 20°C

(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: City of Tampa WWTP
Sanitaire Project #s23698-13

Consulting Engineer: Tetra Tech RTW
Operating Condition: Current Avg. Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Pass		1	1	1	1	1	1	
SWD	ft	17.00	17.00	17.00	17.00	17.00	17.00	
Subm	ft	15.95	15.95	15.95	15.95	15.95	15.95	
Volume	ft³	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	1,146,074.3
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		4	4	4	4	4	4	
Grid Count		1	1	1	1	1	1	24
Dropleg Diameter	inches	8	8	8	8	4	4	
At/Ad		2.53687	2.5945286	3.5674768	7.1349535	27.187433	27.187433	
Diffuser Density	% Floor	39.42%	38.54%	28.03%	14.02%	3.68%	3.68%	
Diffuser Area/Grid	ft²	1,107.27	1,082.67	787.39	393.70	103.32	103.32	14,311
Diffusers/Grid		315	308	224	112	252	252	5,852
90" Gold Series		270	264	192	96			3,288
59"Gold Series		45	44	32	16			548
28" Gold Series								

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Diffuser Type		GSERIES	GSERIES	GSERIES	GSERIES	SSII-9	SSII-9	
Alpha		0.55	0.55	0.55	0.55	0.55	0.55	
Beta		0.95	0.95	0.95	0.95	0.95	0.95	
Theta		1.024	1.024	1.024	1.024	1.024	1.024	
D.O.	mg/l	2	2	2	2	2	2	
Water Temp	°C	30	30	30	30	30	30	
AOR/SOR		0.4217	0.4217	0.4217	0.4217	0.4217	0.4217	0.4217
Oxygen Distribution	%/Zone	32.0%	28.0%	20.0%	10.0%	6.0%	4.0%	100.0%
AOR	lb/day	16,000.0	14,000.0	10,000.0	5,000.0	3,000.0	2,000.0	50,000.0
SOR	lb/day	37,945.1	33,201.9	23,715.7	11,857.8	7,114.7	4,743.1	118,578.3
Air Rate (7)	scfm							

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%							
Mixing Air (8)	scfm	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	
Process Air (for SOR)	scfm	3,930.3	3,380.2	2,412.9	1,225.4	883.1	554.8	
Design Air (1,7)	scfm	3,930.3	3,380.2	2,412.9	1,348.3	1,348.3	1,348.3	13,768.3
Diffuser Air Rate	scfm/Diff.					1.34	1.34	
Diffuser Flux	scfm/ft²	0.89	0.78	0.77	0.86			
Delivered SOR	lb/day	37,945.1	33,201.9	23,715.7	12,877.9	10,291.4	10,291.4	128,323.3
Delivered SOTE	%	38.5%	39.2%	39.2%	38.1%	30.5%	30.5%	37.2%
Pressure @ Top of Dropleg	psig	7.36	7.33	7.32	7.32	7.56	7.56	7.56
Shaft Power	Bhp	159.9	137.2	97.7	54.6	56.1	56.1	572.9

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: City of Tampa WWTP
Sanitaire Project #s23698-13

Consulting Engineer: Tetra Tech RTW
Operating Condition: Current Max Day
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Pass		1	1	1	1	1	1	
SWD	ft	17.00	17.00	17.00	17.00	17.00	17.00	
Subm	ft	15.95	15.95	15.95	15.95	15.95	15.95	
Volume	ft³	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	1,146,074.3
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		4	4	4	4	4	4	
Grid Count		1	1	1	1	1	1	24
Dropleg Diameter	inches	8	8	8	8	4	4	
At/Ad		2.53687	2.5945286	3.5674768	7.1349535	27.187433	27.187433	
Diffuser Density	% Floor	39.42%	38.54%	28.03%	14.02%	3.68%	3.68%	
Diffuser Area/Grid	ft²	1,107.27	1,082.67	787.39	393.70	103.32	103.32	14,311
Diffusers/Grid		315	308	224	112	252	252	5,852
90" Gold Series		270	264	192	96			3,288
59"Gold Series		45	44	32	16			548
28" Gold Series								

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Diffuser Type		GSERIES	GSERIES	GSERIES	GSERIES	SSII-9	SSII-9	
Alpha		0.55	0.55	0.55	0.55	0.55	0.55	
Beta		0.95	0.95	0.95	0.95	0.95	0.95	
Theta		1.024	1.024	1.024	1.024	1.024	1.024	
D.O.	mg/l	1	1	1	1	1	1	
Water Temp	°C	30	30	30	30	30	30	
AOR/SOR		0.4865	0.4865	0.4865	0.4865	0.4865	0.4865	0.4865
Oxygen Distribution	%/Zone	32.0%	28.0%	20.0%	10.0%	6.0%	4.0%	100.0%
AOR	lb/day	28,800.0	25,200.0	18,000.0	9,000.0	5,400.0	3,600.0	90,000.0
SOR	lb/day	59,194.2	51,794.9	36,996.4	18,498.2	11,098.9	7,399.3	184,981.9
Air Rate (7)	scfm							

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%							
Mixing Air (8)	scfm	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	
Process Air (for SOR)	scfm	6,597.7	5,665.5	4,044.0	2,056.6	1,470.3	923.7	
Design Air (1,7)	scfm	6,597.7	5,665.5	4,044.0	2,056.6	1,470.3	1,348.3	21,182.4
Diffuser Air Rate	scfm/Diff.					1.46	1.34	
Diffuser Flux	scfm/ft²	1.49	1.31	1.28	1.31			
Delivered SOR	lb/day	59,194.2	51,794.9	36,996.4	18,498.2	11,098.9	10,291.4	187,874.1
Delivered SOTE	%	35.8%	36.5%	36.5%	35.9%	30.1%	30.5%	35.4%
Pressure @ Top of Dropleg	psig	7.52	7.46	7.41	7.39	7.60	7.56	7.60
Shaft Power	Bhp	273.5	233.2	165.6	84.0	61.4	56.1	885.2

Notes:

(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: City of Tampa WWTP
Sanitaire Project #s23698-13

Consulting Engineer:	Tetra Tech RTW
Operating Condition:	Future Avg. Day
Oxygen Distribution:	Default

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Aeration System Design								
Pass		1	1	1	1	1	1	
SWD	ft	17.00	17.00	17.00	17.00	17.00	17.00	
Subm	ft	15.95	15.95	15.95	15.95	15.95	15.95	
Volume	ft³	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	1,146,074.3
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		4	4	4	4	4	4	
Grid Count		1	1	1	1	1	1	24
Dropleg Diameter	inches	8	8	8	8	4	4	
At/Ad		2.53687	2.5945286	3.5674768	7.1349535	27.187433	27.187433	
Diffuser Density	% Floor	39.42%	38.54%	28.03%	14.02%	3.68%	3.68%	
Diffuser Area/Grid	ft²	1,107.27	1,082.67	787.39	393.70	103.32	103.32	14,311
Diffusers/Grid		315	308	224	112	252	252	5,852
90" Gold Series		270	264	192	96			3,288
59"Gold Series		45	44	32	16			548
28" Gold Series								
Oxygen Transfer								
Diffuser Type		GSERIES	GSERIES	GSERIES	GSERIES	SSII-9	SSII-9	
Alpha		0.55	0.55	0.55	0.55	0.55	0.55	
Beta		0.95	0.95	0.95	0.95	0.95	0.95	
Theta		1.024	1.024	1.024	1.024	1.024	1.024	
D.O.	mg/l	2	2	2	2	2	2	
Water Temp	°C	30	30	30	30	30	30	
AOR/SOR		0.4217	0.4217	0.4217	0.4217	0.4217	0.4217	0.4217
Oxygen Distribution	%/Zone	32.0%	28.0%	20.0%	10.0%	6.0%	4.0%	100.0%
AOR	lb/day	22,400.0	19,600.0	14,000.0	7,000.0	4,200.0	2,800.0	70,000.0
SOR	lb/day	53,123.1	46,482.7	33,201.9	16,601.0	9,960.6	6,640.4	166,009.6
Air Rate (7)	scfm							
Performance								
Mixing Criteria	scfm/ft²	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%							
Mixing Air (8)	scfm	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	
Process Air (for SOR)	scfm	5,812.9	4,993.5	3,564.4	1,812.0	1,298.8	815.9	
Design Air (1,7)	scfm	5,812.9	4,993.5	3,564.4	1,812.0	1,348.3	1,348.3	18,879.5
Diffuser Air Rate	scfm/Diff.					1.34	1.34	
Diffuser Flux	scfm/ft²	1.31	1.15	1.13	1.15			
Delivered SOR	lb/day	53,123.1	46,482.7	33,201.9	16,601.0	10,291.4	10,291.4	169,991.5
Delivered SOTE	%	36.5%	37.2%	37.2%	36.6%	30.5%	30.5%	35.9%
Pressure @ Top of Dropleg	psig	7.47	7.42	7.38	7.36	7.56	7.56	7.56
Shaft Power	Bhp	239.4	204.5	145.4	73.8	56.1	56.1	785.6

Notes:
(1) Design air is the maximum of process air or mixing air
(2) Delivered oxygen based on design air
(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss
(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.
(5) Diffuser Air Flow based on Active Valve Modulation
(6) Blower Pressure Capability also requires consideration of:
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.
B. Potential for increased headloss resulting from diffuser fouling and/or aging.
Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.
C. Increased diffuser submergence during Peak Flow conditions.
(7) Air Flow defined at 20°C
(8) Fine Mixing air based on MOP/8 0.12 scfm/ft²

Sanitaire Project Name: City of Tampa WWTP
Sanitaire Project #s23698-13

Consulting Engineer:	Tetra Tech RTW
Operating Condition:	Future Max Day
Oxygen Distribution:	Default

Aeration System Design

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Pass		1	1	1	1	1	1	
SWD	ft	17.00	17.00	17.00	17.00	17.00	17.00	
Subm	ft	15.95	15.95	15.95	15.95	15.95	15.95	
Volume	ft^3	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	47,753.1	1,146,074.3
No. Parallel Tanks		1	1	1	1	1	1	
No. Trains in Operation		4	4	4	4	4	4	
Grid Count		1	1	1	1	1	1	24
Dropleg Diameter	inches	8	8	8	8	4	4	
At/Ad		2.53687	2.5945286	3.5674768	7.1349535	27.187433	27.187433	
Diffuser Density	% Floor	39.42%	38.54%	28.03%	14.02%	3.68%	3.68%	
Diffuser Area/Grid	ft^2	1,107.27	1,082.67	787.39	393.70	103.32	103.32	14,311
Diffusers/Grid		315	308	224	112	252	252	5,852
90" Gold Series		270	264	192	96			3,288
59"Gold Series		45	44	32	16			548
28" Gold Series								

Oxygen Transfer

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Diffuser Type		GSERIES	GSERIES	GSERIES	GSERIES	SSII-9	SSII-9	
Alpha		0.55	0.55	0.55	0.55	0.55	0.55	
Beta		0.95	0.95	0.95	0.95	0.95	0.95	
Theta		1.024	1.024	1.024	1.024	1.024	1.024	
D.O.	mg/l	1	1	1	1	1	1	
Water Temp	°C	30	30	30	30	30	30	
AOR/SOR		0.4865	0.4865	0.4865	0.4865	0.4865	0.4865	0.4865
Oxygen Distribution	%/Zone	32.0%	28.0%	20.0%	10.0%	6.0%	4.0%	100.0%
AOR	lb/day	40,320.0	35,280.0	25,200.0	12,600.0	7,560.0	5,040.0	126,000.0
SOR	lb/day	82,871.9	72,512.9	51,794.9	25,897.5	15,538.5	10,359.0	258,974.7
Air Rate (7)	scfm							

Performance

Parameter	Units	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Totals/Overall
Mixing Criteria	$scfm/ft^2$	0.12	0.12	0.12	0.12	0.12	0.12	
Safety Factor	%							
Mixing Air (8)	scfm	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	1,348.3	
Process Air (for SOR)	scfm	9,806.9	8,410.3	6,003.1	3,056.4	2,162.3	1,358.5	
Design Air (1,7)	scfm	9,806.9	8,410.3	6,003.1	3,056.4	2,162.3	1,358.5	30,797.5
Diffuser Air Rate	scfm/Diff.					2.15	1.35	
Diffuser Flux	$scfm/ft^2$	2.21	1.94	1.91	1.94			
Delivered SOR	lb/day	82,871.9	72,512.9	51,794.9	25,897.5	15,538.5	10,359.0	258,974.7
Delivered SOTE	%	33.7%	34.4%	34.4%	33.8%	28.7%	30.4%	33.6%
Pressure @ Top of Dropleg	psig	7.84	7.70	7.59	7.54	7.86	7.56	7.86
Shaft Power	Bhp	420.4	355.2	250.7	126.9	93.0	56.5	1,323.9

Notes:

(1) Design air is the maximum of process air or mixing air

(2) Delivered oxygen based on design air

(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss

(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.

(5) Diffuser Air Flow based on Active Valve Modulation

(6) Blower Pressure Capability also requires consideration of:

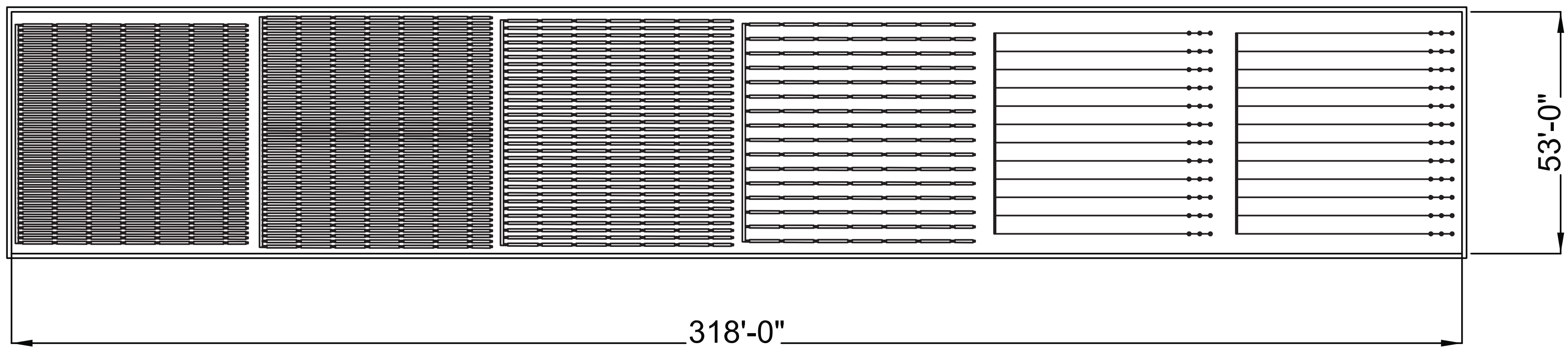
A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.

B. Potential for increased headloss resulting from diffuser fouling and/or aging. Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.

C. Increased diffuser submergence during Peak Flow conditions.

(7) Air Flow defined at 20°C

(8) Fine Mixing air based on MOP/8 0.12 $scfm/ft^2$



Single Train Information

Grid No	Grid Count	Drop Leg Ø"	Header Count	Header Spc, ft.	Header Len, ft.	Diff/ Grid	At/ Ad	Diff/ Train
1	1	8	45	1.08	51.08	315	2.54	315
2	1	8	44	1.17	51.08	308	2.59	308
3	1	8	32	1.58	51.08	224	3.57	224
4	1	8	16	3.17	51.08	112	7.13	112
5	1	4	12	4.00	47.42	252	27.5	252
6	1	4	12	4.00	47.42	252	27.2	252

Total Diffs/Train 1027

Note: Some headers may be omitted for clarity

PRELIMINARY – THIS DRAWING IS NOT INTENDED FOR CONTRACT DOCUMENTS, SUBMITTALS OR CONSTRUCTION

Sanitaire a xylem brand BROWN DEER, WISCONSIN 53223	CUST NO.	THIS DRAWING IS THE PROPERTY OF XYLEM AND IS SUBMITTED IN CONFIDENCE. IT IS NOT TO BE DISCLOSED, USED OR DUPLICATED WITHOUT PERMISSION OF XYLEM.	City of Tampa WWTP Gold Series Aeration System	DRAWN BY IM	DATE 2/12/13	MODEL	JOB s23698-13
	DWG NO.			CHKD BY	DATE		SHEET
				APPVD BY	DATE		

Water & Wastewater

Technical Specification

Sanitaire Gold Series 1650.010

Engineered for life

Product Description

A low flux, high density strip diffuser for an efficient aeration and mixing process of waste water. The product is completely compatible with other Sanitaire products like the disc diffuser system.

Denomination

Product code	1650.010
Installation	Tank floor installation with anchor bolts

Process data

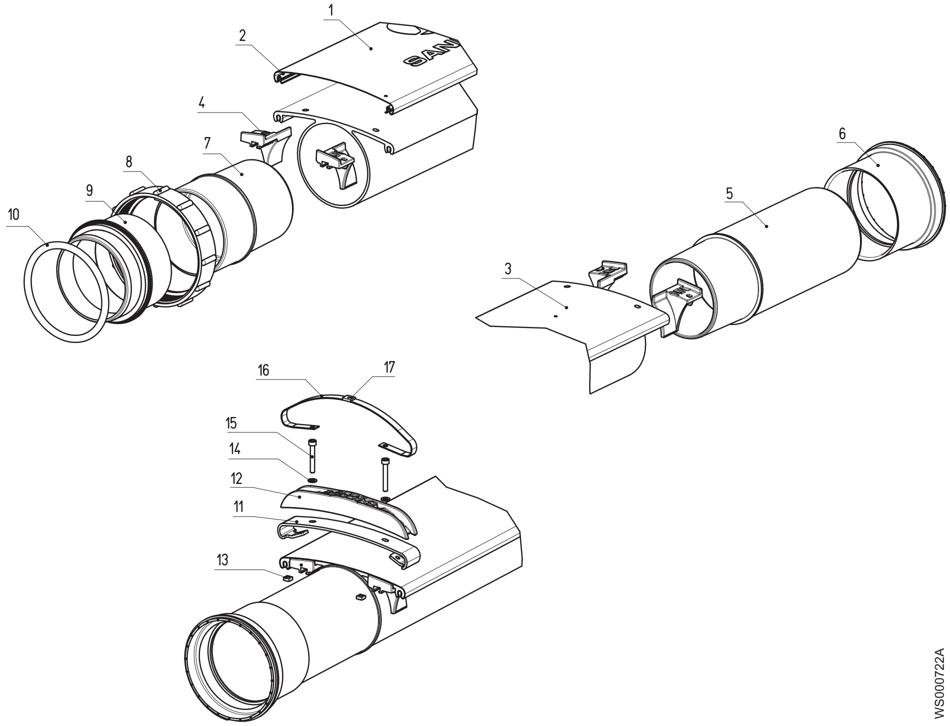
Parameter	Minimum value	Maximum value
Liquid temperature	+2°C (+36°F)	+38°C (+100°F)
Pipe average temperature (at diffuser)	-10°C (+14°F)	+40°C (+104°F)
Pipe average temperature (at dropleg)	—	+55°C (+131°F)

This product is only for use with municipal wastewater.

Dimensions and weights

Product length	Product weight
700 mm (28 in.)	5.6 kg (12.3 lbs)
1500 mm (59 in.)	8.4 kg (18.5 lbs)
2286 mm (90 in.)	10 kg (22 lbs)

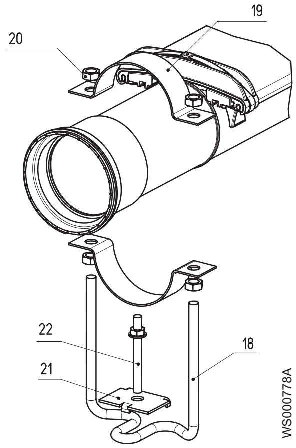
Materials



Factory assembled parts

Position number	Denomination	Material
1	Membrane	Polyurethane
2	O-ring cord	Silicone
3	Holder	PVC-U, 2% TiO_2
4	Wing support	PVC-U, 2% TiO_2
5	Pipe coupling	PVC-U, 2% TiO_2
6	Socket	PVC-U, 2% TiO_2
7	Pipe coupling	PVC-U, 2% TiO_2
8	Retaining ring	PVC-U, 2% TiO_2
9	Spigot	PVC-U, 2% TiO_2
10	O-ring	EPDM
11	Gasket	EPDM
12	End seal holder	PVC-U, 2% TiO_2
13	Square nut	SS 316
14	Washer	SS 316
15	Screw	SS 316
16	Strap	SS 316
17	Lock unit	SS 316

Parts assembled on site



Position number	Denomination	Material
18	Pipe support	SS 304, SS 316
19	Clamp	SS 304, SS 316
20	Nut	SS 316
21	Locating plate	SS 316
22	Anchor bolt	SS 304, SS 316

Installation alternatives

Dimensions

Range type	Range
Distance from wall (parallel to product)	300 mm (0.98 ft.) — 1000 mm (3.28 ft.)
Distance from wall (perpendicular to product)	Max 1200 mm (3.94 ft.)
Spacing between products	136 mm — 7641 mm
Orifice size	3.175 mm (1/8 in.)

Guide support

Metric

Material	Dimension	Height
SS 304	M8	250 or 330 mm
	M12	250 or 330 mm
SS 316	M8	250 or 330 mm
	M12	250 or 330 mm

Imperial

Material	Dimension	Height
SS 304	5/16 in.	10 or 13 in.
	1/2 in.	10 or 13 in.
SS 316	5/16 in.	10 or 13 in.
	1/2 in.	10 or 13 in.

Anchor bolt

Metric

Material	Dimension	Type
SS 316	M10	Mechanical or chemical

Imperial

Material	Dimension	Type
SS 304	3/7 in.	Mechanical or chemical
SS 316	3/8 in.	Mechanical or chemical

Installation,
Operation, and
Maintenance Manual

Sanitaire, Gold Series

Table of Contents

Introduction and Safety

Introduction

Purpose of this manual

The purpose of this manual is to provide necessary information for:

- Installation
- Operation
- Maintenance

CAUTION:
Read this manual carefully before installing and using the product. Improper use of the product can cause personal injury and damage to property, and may void the warranty.

NOTICE:
Save this manual for future reference, and keep it readily available at the location of the unit.

Other manuals

See also the safety requirements and information in the original manufacturer's manuals for any other equipment furnished separately for use in this system.

Safety

DANGER:
- Operating, installing, or maintaining the unit in any way that is not covered in this manual could cause death, serious personal injury, or damage to the equipment. This includes any modification to the equipment or use of parts not provided by Xylem. If there is a question regarding the intended use of the equipment, please contact a Xylem representative before proceeding.
- Do not change the service application without the approval of an authorized Xylem representative.

CAUTION:
- The operator must be aware of safety precautions to prevent physical injury.
- Read this manual carefully before installing and using the product. Improper use of the product can cause personal injury and damage to property, and may void the warranty.

You must observe the instructions contained in this manual. Failure to do so could result in physical injury, damage, or delays.

The safety information presented here is organized into the following areas:

- An explanation of safety symbols and hazard levels, see *Safety terminology and symbols* (page 4)
- Safety precautions to prevent physical injury to personnel, see *User safety* (page 5)
- Precautions for protecting the environment, see *Environmental safety* (page 7)

Safety terminology and symbols

About safety messages

It is extremely important that you read, understand, and follow the safety messages and regulations carefully before handling the product. They are published to help prevent these hazards:

- Personal accidents and health problems
- Damage to the product
- Product malfunction

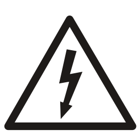
Hazard levels

Hazard level	Indication
 DANGER:	A hazardous situation which, if not avoided, will result in death or serious injury
 WARNING:	A hazardous situation which, if not avoided, could result in death or serious injury
 CAUTION:	A hazardous situation which, if not avoided, could result in minor or moderate injury
NOTICE:	• A potential situation which, if not avoided, could result in undesirable conditions • A practice not related to personal injury

Hazard categories

Hazard categories can either fall under hazard levels or let specific symbols replace the ordinary hazard level symbols.

Electrical hazards are indicated by the following specific symbol:



Electrical Hazard:

These are examples of other categories that can occur. They fall under the ordinary hazard levels and may use complementing symbols:

- Crush hazard
- Cutting hazard
- Arc flash hazard

User safety

General safety rules

These safety rules apply:

- Machinery in the work area must be de-energized (lockout/tagout) before starting work.
- Pay attention to the risks presented by gases and vapors in the work area.
- Always bear in mind the risk of drowning, electrical dangers, and burn injuries.

Safety equipment

Use personal protective equipment in accordance with applicable laws, regulations, and guidelines.

Personal protective equipment which may be required includes:

- Hard hat
- Safety goggles, preferably with side shields
- Protective shoes
- Protective gloves
- Breathing apparatus
- Hearing protection
- First-aid kit
- Safety devices

NOTICE:

Never operate a unit unless safety devices are installed. Also see specific information about safety devices in other chapters of this manual.

Electrical connections

Electrical connections must be made by certified electricians in compliance with all applicable codes and regulations. For more information about requirements, see sections dealing specifically with electrical connections.

Confined spaces

To ensure your own safety when working in a confined space, follow this procedure.

DANGER:

Before entering the work area, make sure that the atmosphere contains sufficient oxygen and no toxic gases.

WARNING:

The chamber or tank where the equipment is installed should be treated as a confined space. Always follow the applicable safety laws, regulations and guidelines for enclosed spaces.

Never work alone in a confined space. Before entering the space, check that the following requirements are complied with:

- The atmosphere contains sufficient oxygen
- The atmosphere contains no explosive or toxic gases
- All energy sources are locked out and tagged out
- Adequate ventilation is in place
- There is a clear path of retreat
- Monitoring is in place for hazards which can develop after entering the confined space

Drowning

Spaces that are not fully drained or dry can pose a risk of drowning. It takes relatively little standing water or other liquid to create a drowning hazard. For example, insufficient oxygen or the presence of a toxic material can make a worker unconscious, which makes them vulnerable to drowning if they fall face down into a small pool of water. Never work alone where there is a risk of drowning.

WARNING:

Always bear in mind the risk of drowning.

Biological hazards

The product is designed for use in liquids that can be hazardous to your health. Observe these rules when you work with the product:

- Make sure that all personnel who may come into contact with biological hazards are vaccinated against diseases to which they may be exposed.
- Observe strict personal cleanliness.

WARNING:

Rinse the unit thoroughly with clean water before working on the unit.

Organic dust

WARNING:

- Rinse the components in water after dismantling.
- Rinse the unit thoroughly with clean water before working on the unit.

When performing maintenance on the product inside or close to the tank or pit where the product is used, workers may be exposed to organic dust contaminated with microorganisms.

Employers and workers can minimize the risks of exposure to organic dust by taking the following precautions:

- Be aware of the adverse health effects of breathing organic dust.
- Use engineering controls such as local exhaust ventilation, and wet methods of dust suppression to minimize exposure to organic dust.
- Use appropriate respirators when exposure to organic dust cannot be avoided.
- Follow all health and safety rules and local codes and ordinances.

Working with solvents

WARNING:

Potential fire and explosion hazard: Before working in this area, clear all dust and flammable material from the work area and provide sufficient ventilation.

CAUTION:

These chemicals can cause physical injury. Contact the supplier for information and advice for proper handling precautions and procedures.

Be aware of changing conditions when using solvents. Follow all health and safety rules and local codes and ordinances.

Wash the skin and eyes

Follow these procedures for chemicals or hazardous fluids that have come into contact with your eyes or your skin:

Condition	Action
Chemicals or hazardous fluids in eyes	1. Hold your eyelids apart forcibly with your fingers. 2. Rinse the eyes with eyewash or running water for at least 15 minutes. 3. Seek medical attention.
Chemicals or hazardous fluids on skin	1. Remove contaminated clothing. 2. Wash the skin with soap and water for at least 1 minute. 3. Seek medical attention, if necessary.

Environmental safety

The work area

Always keep the station clean to avoid discharge or release of environmentally hazardous substances, and to aid in detecting inadvertent discharges.

Waste and emissions regulations

Observe these safety regulations regarding waste disposal and release of substances:

- Appropriately dispose of all waste.
- Handle and dispose of used or process liquids in compliance with applicable environmental regulations.
- Clean up all spills in accordance with safety and environmental procedures.
- Report all environmental discharges to the appropriate authorities.

WARNING:

Do NOT send the product to the Xylem manufacturer if it has been contaminated by any nuclear radiation. Inform Xylem so that accurate actions can take place.

Recycling guidelines

Always follow local laws and regulations regarding recycling.

Product warranty

Coverage

Xylem undertakes to remedy faults in all equipment supplied under these conditions:

- The faults are due to defects in design, materials, or workmanship.
- The faults are reported to a Xylem representative within the warranty period.
- The product is used only under the conditions described in this manual.
- All service and repair work is done according to the instructions in this manual.
- Genuine parts from the original equipment manufacturers are used.

Replacement does not include labor for removal or re-installation of the unit or parts deemed defective.

Limitations

The warranty does not cover faults caused by these situations:

- Deficient maintenance
- Improper installation
- Modifications or changes to the product and installation made without consulting Xylem

- Incorrectly executed repair work
- Normal wear and tear

Xylem assumes no liability for these situations:

- Bodily injuries
- Material damages
- Economic losses

Warranty claim

Xylem products are high-quality products with expected reliable operation and long life. However, should the need arise for a warranty claim, then contact your Xylem representative.

Spare parts

Xylem guarantees that spare parts will be available for 10 years after the manufacture of this product has been discontinued.

Transportation and Storage

Inspect the delivery

Inspect the package

1. Inspect the package for damaged or missing items upon delivery.
2. Note any damaged or missing items on the receipt and freight bill.
3. File a claim with the shipping company if anything is out of order.

   If the product has been picked up at a distributor, make a claim directly to the distributor.

Inspect the product

1. Inspect the product to determine if any parts have been damaged or are missing.
2. If applicable, unfasten the product by removing any screws, bolts, or straps.

   For your personal safety, be careful when you handle nails and straps.
3. Contact your sales representative if anything is out of order.

Transportation guidelines

Precautions

WARNING:
- Stay clear of suspended loads.
- Observe accident prevention regulations in force.

Lifting

Lifting equipment is always required when handling the shipment. The equipment components can be lifted with either a crane or a forklift.

WARNING:
- Crush hazard. The unit and the components can be heavy. Use proper lifting methods and wear steel-toed shoes at all times.

NOTICE:
- Lift and handle the product carefully, using suitable lifting equipment.
- The product must be securely harnessed for lifting and handling. Use eyebolts or lifting lugs if available.

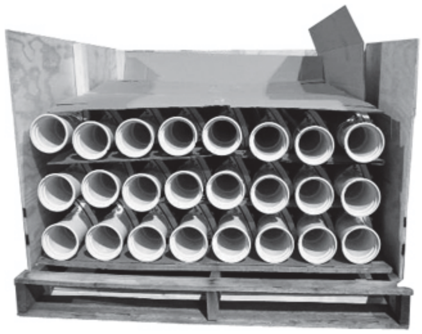
Lifting with crane

Cranes used to lift the equipment components must fulfill the following requirements:
- The lifting equipment must be able to hoist the equipment components straight up and down, preferably without the need for resetting the lifting hook.
- The lifting strap must be fastened to the lifting points on top of the package.

1. Check that the site where the equipment components will be placed has a clean and level surface.
2. Fasten a suitable lifting strap or sling to the lifting points on top of the pallet, if used.

3. If the equipment components are secured to the flatbed or other surface, then cut the transportation straps.
4. Lift using proper lifting equipment.
5. Place the equipment components on a clean, rigid, horizontal surface so that they cannot fall over.

Lifting with pallet and forklift



1. Align the forklift prongs with the forklift hole(s), and insert the prongs.
2. If the pallet is secured to the flatbed or other surface, then cut the transportation straps.
3. Lift the pallet and move it to its new position.
4. Place the pallet on a clean, rigid, horizontal surface so that it cannot fall over.

Storage guidelines

Dry storage location

The storage site must be available before equipment arrival. The product must be stored in a level, covered, and dry location free from heat, dirt, and vibrations. The diffusers must be kept in the original packaging until the final installation unless they are pre-mounted on the pipe.

NOTICE:

- Do not stack shipping units.
- Do not place heavy weights on the packed product.
- Protect the product against humidity, heat sources, and mechanical damage.
- Do not cover the pipe components with plastic. Excessive heat build-up can damage plastic pipes and void the warranty.
- Risk of wear. Make sure the equipment is clean before it is placed into service.

System Description

Diffusers included

Type	Model
Fine bubble	Gold Series

Diffuser design

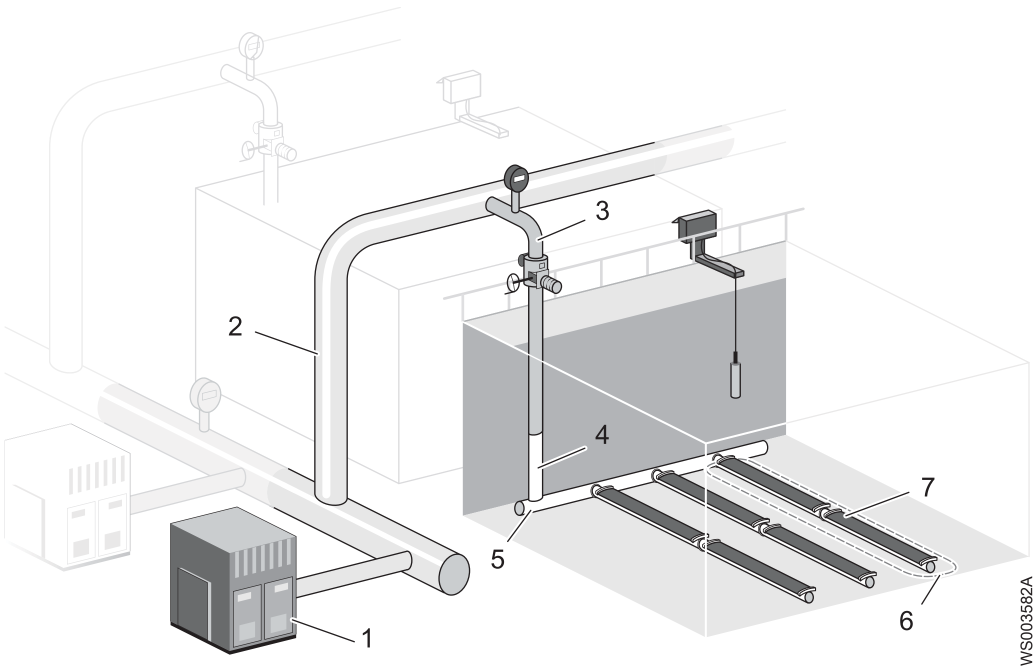
A low flux, high density fine bubble panel diffuser designed for an efficient and reliable aeration and mixing process of industrial and municipal wastewater. The fine bubble diffuser is completely compatible with other Sanitaire aeration equipment.

Intended use

The product is only for use with municipal and industrial wastewater. Always follow the limits given in *Application limits* (page 46). If there is a question regarding the intended use of the equipment, please contact a sales representative before proceeding.

Definition of system components

The main components in an aeration system are shown in the figure below.



Position number	Description	Definition
1	Blower	The device that distributes the air to the air main.
2	Air main	The pipe that connects the blower to the upper dropleg.
3	Upper dropleg	The pipe that connects the air main to the lower dropleg.
4	Lower dropleg	The pipe that connects the upper dropleg to the manifold.
5	Manifold	The pipe that connects the lower dropleg to the air distributor. There are no holders mounted on this pipe.

Position number	Description	Definition
6	Air distributor	A set of products (pipes, couplings, and holders with diffusers) from the manifold to the end cap.
7	Holder with diffuser	The diffuser is attached to the holder. It forms part of the air distributor, and distributes the air to the liquid.

Installation

Precautions

WARNING:
Always follow safety guidelines when working on the product. See *Introduction and Safety* (page 3).

Requirements

The following requirements apply:

- Never work alone.
- Make sure to have a clear path of retreat.
- Make sure that the work area is properly ventilated.
- Provide a suitable barrier around the work area, for example a guard rail.
- Check the explosion risk before you weld or use electrical hand tools.
- Ensure that welding or construction work does not damage the aeration system equipment.
- Use the installation drawings, containing the required part number designation, in order to ensure proper installation.
- Remove all debris from the air main before installation.

The figures in the instructions can differ from the delivered products.

Leveling guidelines

To ensure an installation where maximum system efficiency is obtained, and where leaks, adjustments, and damage to products are minimized, follow these guidelines:

- Always use the highest point of the tank floor as a reference when leveling. The height of the grid should be as low as possible at this point.
- Use a level system which ensures installation within the given tolerance (6 mm [¼ in.] horizontally).
- Allow for movement of the pipes when securing the clamps.
- Align pipes correctly before couplings are assembled.

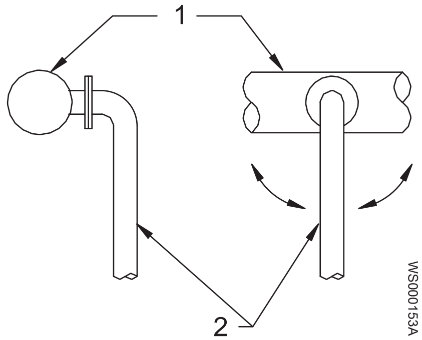
Dropleg and manifold installation

Prerequisites

- Always use the highest point of the tank floor as a reference when leveling.
- Ensure that the air filtration equipment is installed and operating.
- Ensure that all dirt and debris are removed from the air main.

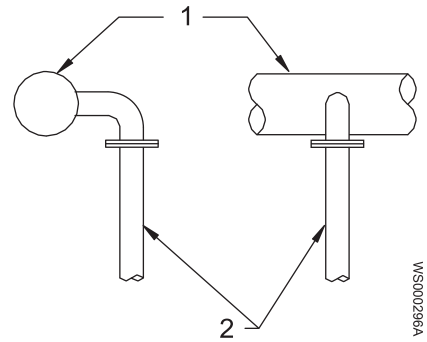
  If air blowers are used, then follow the instructions from the manufacturer. Blowers can require a minimum back pressure when operating.

Upper dropleg connection requirement



1. Air main
2. Upper dropleg

Figure 1: Vertical flange connection



1. Air main
2. Upper dropleg

Figure 2: Horizontal flange connection

Ensure that the upper dropleg is attached to the air main, and vertical to its centerline. Refer to the installation drawings. The dropleg must be attached loosely in order to allow easy installation of the lower dropleg.

- If the dropleg is connected with a vertical flange, then ensure that it can be swung to the side.
- If the dropleg is connected with a horizontal flange, then ensure that it can be easily removed.

Ensure that the end plugs of the upper droplegs are removed.

Support types

There are three types of manifold supports:

- Single anchor support that is used for 110 mm (4 in.) diameter manifolds.
- Support without strut that is used for 160 mm (6 in.) diameter or greater manifolds where the manifold centerline elevation is less than 457 mm (18 in.) from the floor.
- Support with strut that is used for 160 mm (6 in.) diameter or greater where the manifold centerline elevation is above 457 mm (18 in.) from the floor.

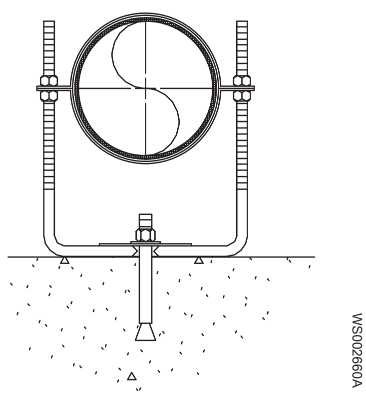


Figure 3: Single anchor support

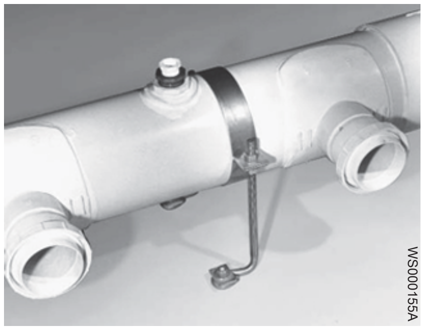
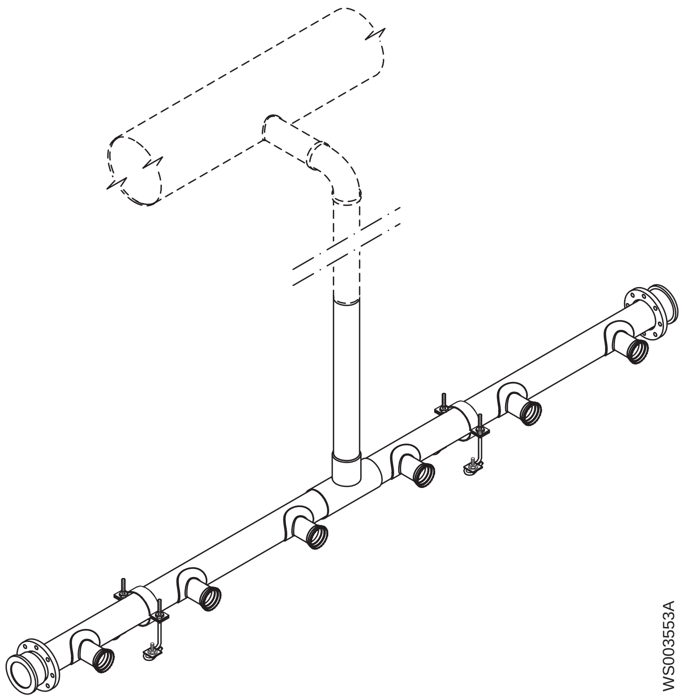


Figure 4: Support without strut

Figure 5: Support with strut

Installation procedure overview

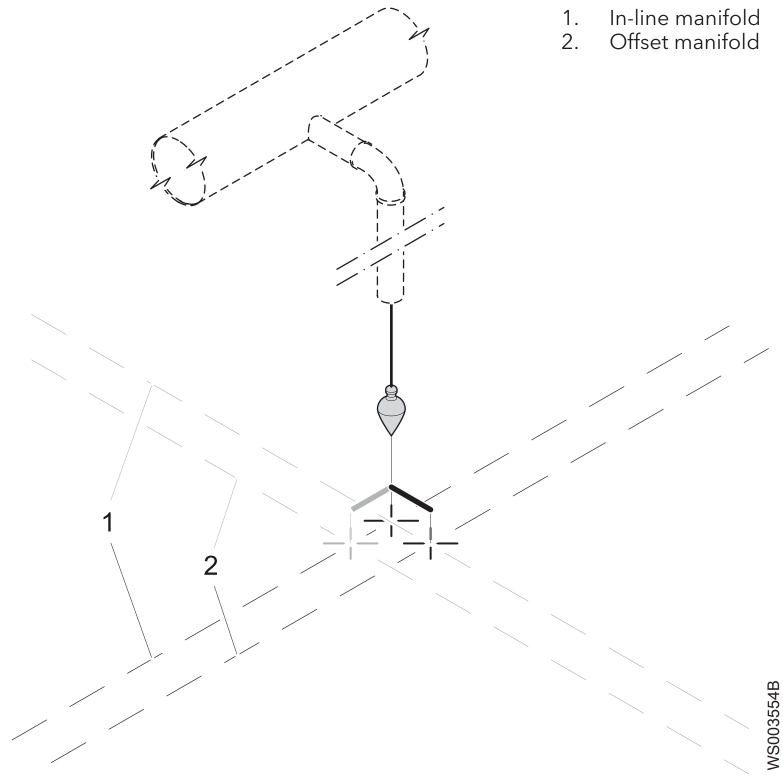


The manifold installation includes the following steps:

- *Lay out the manifold centerline* (page 15)
- *Lay out the manifold support locations* (page 16)
- *Install the manifold anchors and supports* (page 17)
- *Assemble the manifold pipe sections* (page 19)
- *Install the lower dropleg* (page 21)

Lay out the manifold centerline

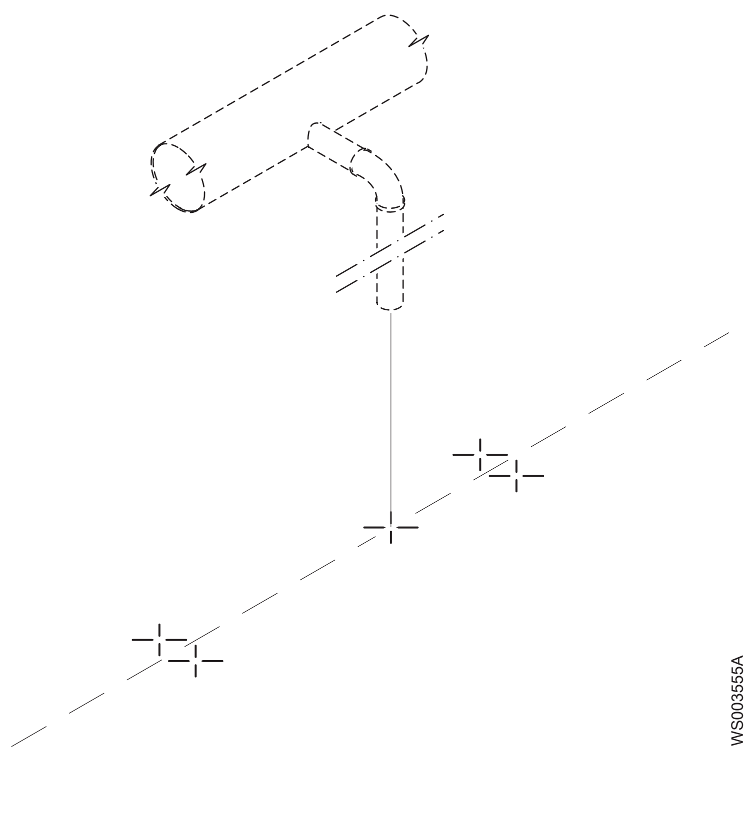
The dropleg connection to the manifold is located directly under the dropleg. In some installations, the dropleg connection is offset.



1. In-line manifold
2. Offset manifold

1. Locate the centerline of the manifold.
   Use the installed upper dropleg and the installation drawings.
2. Mark clearly the position on the floor.

Lay out the manifold support locations



1. Locate and layout all manifold support locations.

   Use the installation drawings and shippings lists.
2. Mark clearly the positions on the floor.

Install the manifold anchors and supports

The manifold sections must be placed according to the manifold and anchor layout before the anchors are installed.

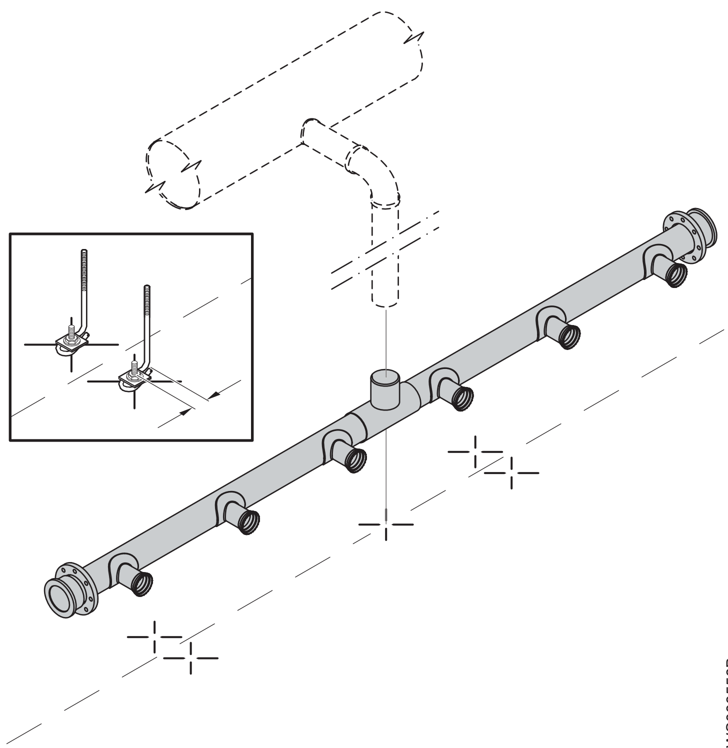
Always use the highest point of the tank floor as a reference when leveling.

1. Lower the manifold sections into the tank.
2. Place the sections according to the layout and double check for possible interference.

   Use the reference numbers from the installation drawings to identify the pipe sections.
3. Check, and if necessary, correct the positions of the support anchors.

   Consider the offset from the anchor position to the center line of the support, and install all supports in the same direction.

   Ensure that the maximum support spacing does not exceed 2400 mm or 8 ft.



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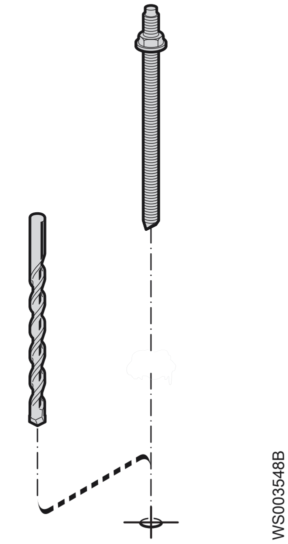
4. Install the manifold support anchors according to the instructions from the manufacturer.

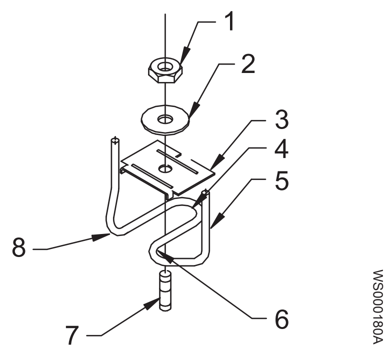
   The threaded projection from the floor level must correspond to the installation drawing anchor table.



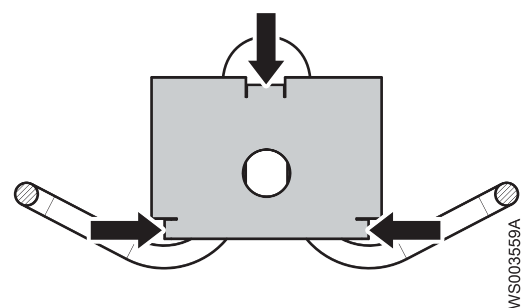
The tightening torque values are listed in the installation instructions from the anchor bolt manufacturer.

5. On a single anchor support, install the locating plate with the two bent prongs in front, inside the support rod, and the single prong to the back, inside the u-bend.

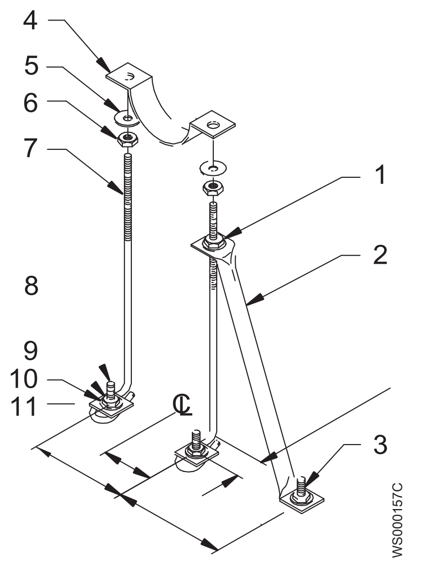
   Install all supports in the same direction.



1. Hexagon nut
2. Flat washer
3. Locating plate
4. Back of support
5. Support rod
6. Inside of support rod
7. Anchor bolt
8. Front of support rod



6. Install the struts, if applicable.
7. Install the hexagon nuts and place the lower pipe support clamp on them.



1. Hexagon nut
2. Strut
3. Anchor bolt
4. Clamp
5. Washer
6. Hexagon nut
7. Rod
8. Anchor bolt
9. Hexagon nut
10. Washer, round
11. Washer, square

8. Use the installation drawings and a level system to find the correct clamp flange elevation.

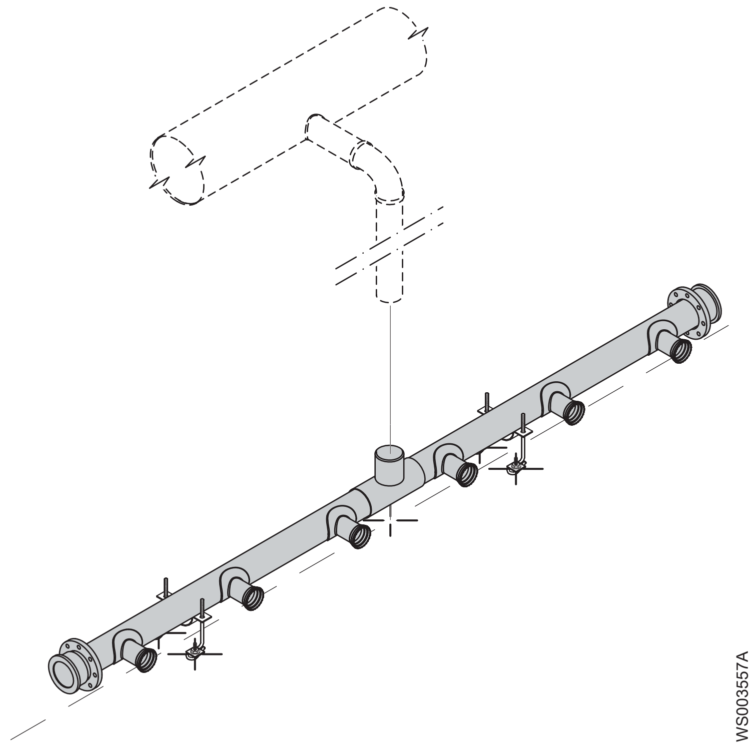
   The correct elevation is equal to the manifold center line, and the tolerance is ± 6 mm (¼ in.).

Assemble the manifold pipe sections

CAUTION:
These chemicals can cause physical injury. Contact the supplier for information and advice for proper handling precautions and procedures.

1. Examine the manifold sections.

   If the sections are dirty and contain debris from storage, then flush with water before installation.
2. Remove all protective dust covers from the pipe ends and connections.
3. Place the manifold sections in the lower part of the support clamp.



4. Connect the manifolds:
   a) Connect flanges with bolts loosely.
   b) Connect joints with glue.
   c) Connect spline couplings without tightening.
5. Install the upper part of the support clamp with washers and nuts.
   Tighten loosely.
6. Level the manifold sections which attach to the droplegs.
   - For in-line manifolds, ensure that the air distributor connections are horizontal.
   - For raised manifolds, ensure that the air distributor connections are vertical.

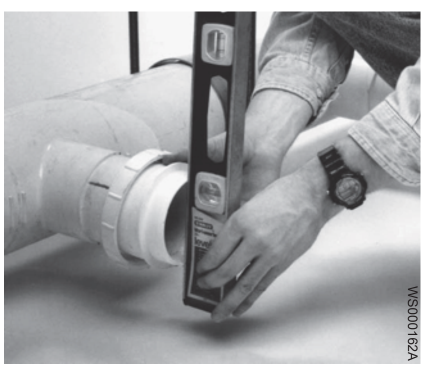


Figure 6: In-line manifold

Figure 7: Raised manifold

7. Secure the clamps on the sections which attach to the droplegs by tightening the hexagon nuts.
   Ensure that the manifold is horizontal.
8. Install all manifold sections according to the installation drawings.
   Do not secure the clamps on these sections at this point.
9. Install the lower dropleg according to *Install the lower dropleg* (page 21).
10. Complete the manifold installation:

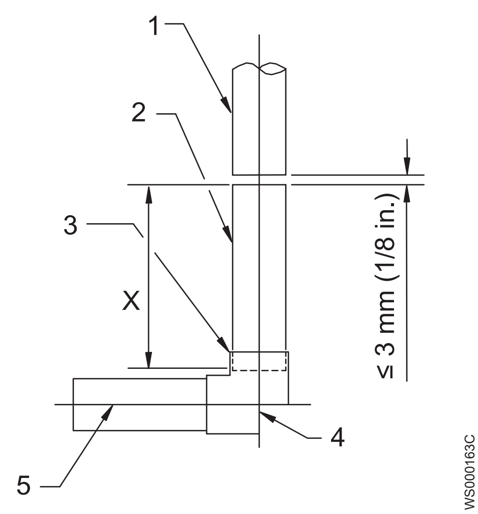
a) Level the remaining manifold sections and ensure that the air distributor connections are level.
b) Tighten the flange connections between the manifold sections.
c) Secure the pipes by tightening the hexagon nuts on the upper part of the clamps.

Install the lower dropleg

CAUTION:
These chemicals can cause physical injury. Contact the supplier for information and advice for proper handling precautions and procedures.

An in-line manifold (see figure below) does not require a feed pipe. See the installation drawings.

1. Install the feed pipe and support, if applicable. This is only applicable to an offset manifold.
   a) Glue the feed pipe and fittings.
   b) Install the feed pipe and the supports, if applicable.



1. Upper dropleg
2. Lower dropleg, cut to length X
3. Socket fitting
4. Upper dropleg centerline
5. Feed pipe centerline

Figure 8: Parts between dropleg and manifold, offset manifold

2. Measure the distance X from the end of the installed upper dropleg to the insertion depth of the socket fitting.
   If a flange connection is used, then consider the flange, the socket depth, and the gasket thickness.
3. Remove the upper dropleg out of the work area.
4. Cut or trim the lower dropleg to the measured distance.
5. Glue the lower dropleg into the socket fitting.
6. Reinstall the upper dropleg.
   Ensure that the gap between the upper and lower dropleg is maximum 3 mm (1/8 in.).

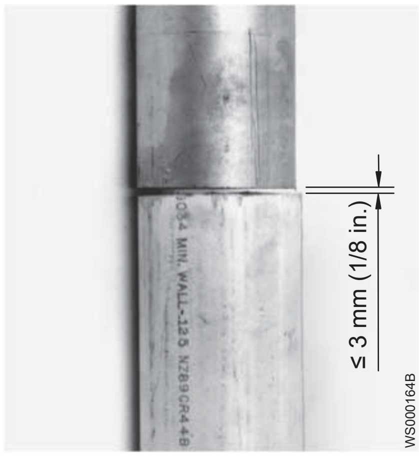


Figure 9: Upper and lower dropleg

7. Install the clamp coupling or tighten the flange connection.
   Tighten the clamp coupling bolts to a torque of 70–75 Nm (50–55 ft-lbs).

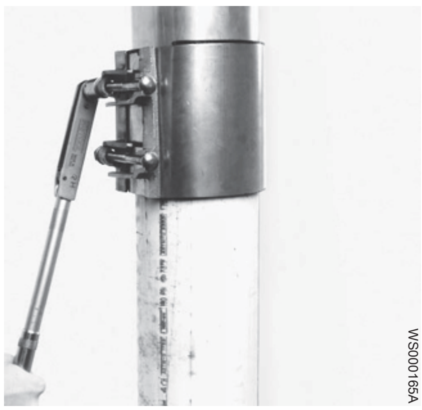


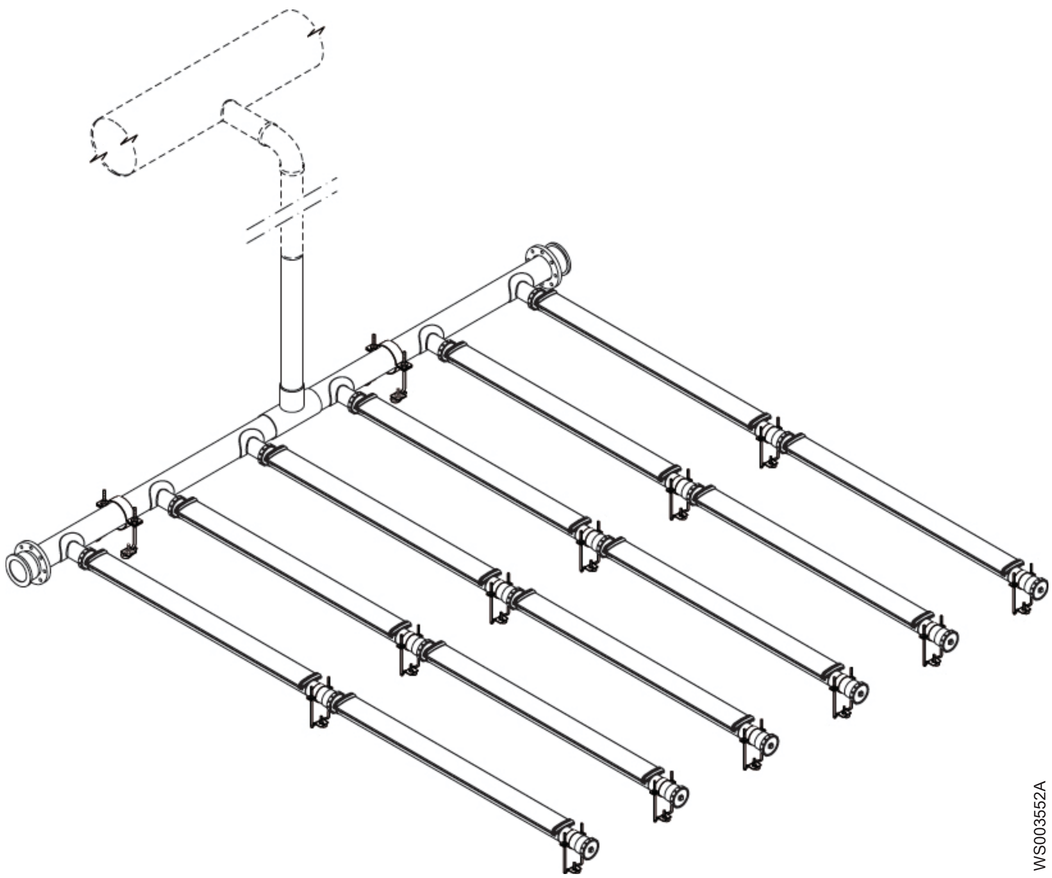
Figure 10: Example of clamp coupling

Figure 11: Example of flange connection

8. Tighten the upper dropleg to the air main.
9. Complete the manifold installation according to the last step in *Assemble the manifold pipe sections* (page 19).

Air distributor installation

Installation procedure overview



The installation includes the following steps:

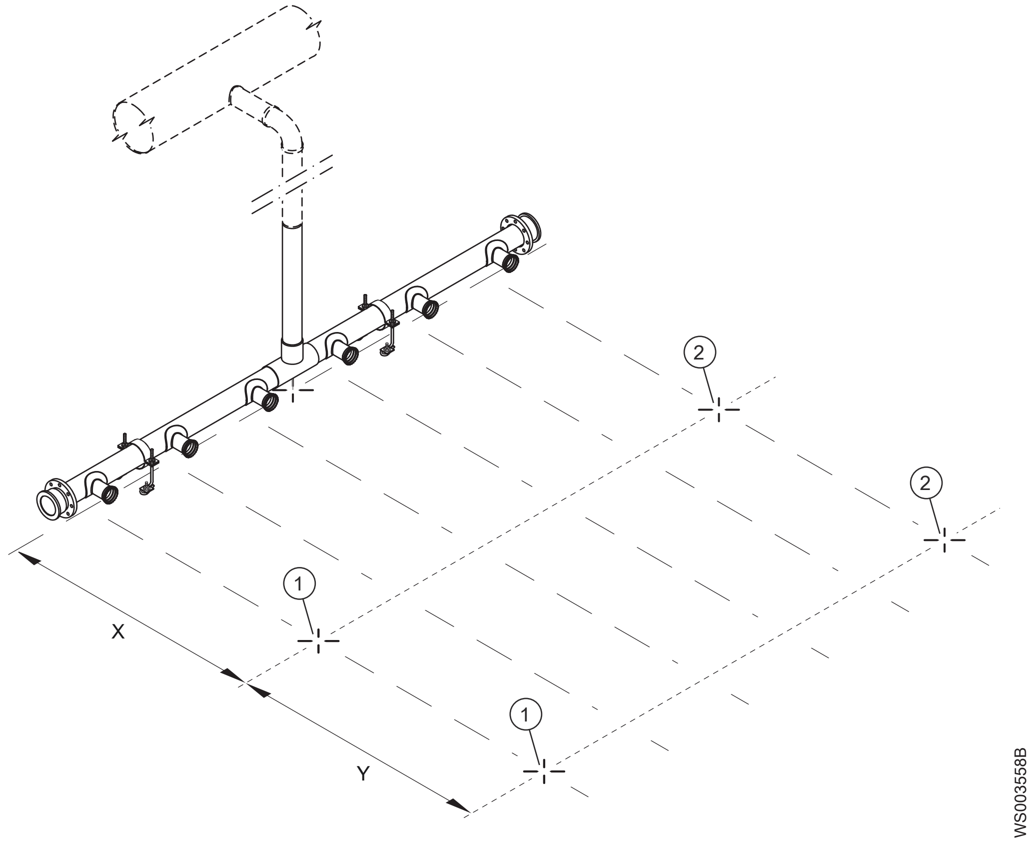
- *Lay out the air distributor support locations* (page 23)
- *Install the air distributor anchors and supports* (page 24)
- *Assemble an air distributor section* (page 25)
  - *Place the sections* (page 27)
  - *Assemble with spline couplings* (page 27)
  - *Assemble with expansion couplings* (page 28)
  - *Leval and tighten the air distributors* (page 30)

Lay out the air distributor support locations

1. Lay out the centerline for each air distributor.

   Use the installation drawings and the manifold air distributor connections. Start measuring from the center line of the manifold.
2. Mark the air distributor support locations for the first air distributor from one side. See (1) in the figure below.

   The distance between the manifold center line and first support location is marked X in the figure below. The distance to the second support location is marked Y.



3. Ensure that there is no interference and make the required adjustments.
   Support locations can be adjusted as required within the pipe coupling allowance. Place as close to the middle as possible.

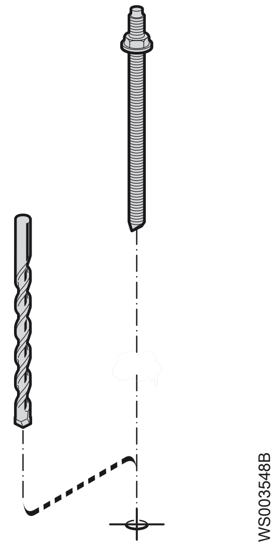
4. Mark the support locations for the air distributor located at the opposite end of the manifold. See (2) in the figure above.
5. Use a chalk line to mark all support locations between the outside layout lines.

Install the air distributor anchors and supports

Sloped floors can require the use of several different support types or support rod diameters. Refer to the installation drawings for identification of the correct support at each location.

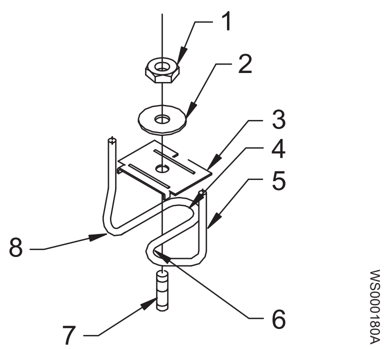
1. Install the anchor bolts according to the instructions from the manufacturer.

The threaded projection from the floor level must correspond to the installation drawing anchor table.

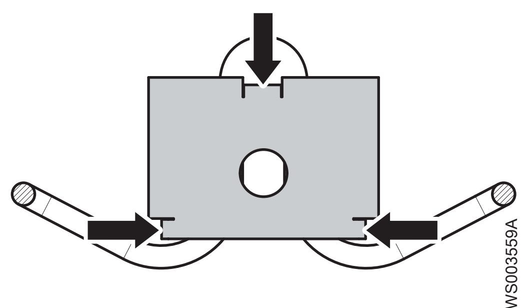


2. Install the locating plate with the two bent prongs in front, inside the support rod, and the single prong to the back, inside the u-bend.

   Install all supports in the same direction.



1. Hexagon nut
2. Flat washer
3. Locating plate
4. Back of support
5. Support rod
6. Inside of support rod
7. Anchor bolt
8. Front of support



3. Tighten the hexagon nut to the recommended torque value as listed by the anchor bolt manufacturer.
4. Using a level system, find the correct elevation to put the hexagon nut on all air distributor supports.

   The correct elevation is the air distributor center line, shown on the installation drawings. The difference in height can not exceed a tolerance of ± 6 mm (¼ in.) from one side to the other throughout the whole grid.
5. Install the lower clamp sections on all air distributor supports.

Assemble an air distributor section

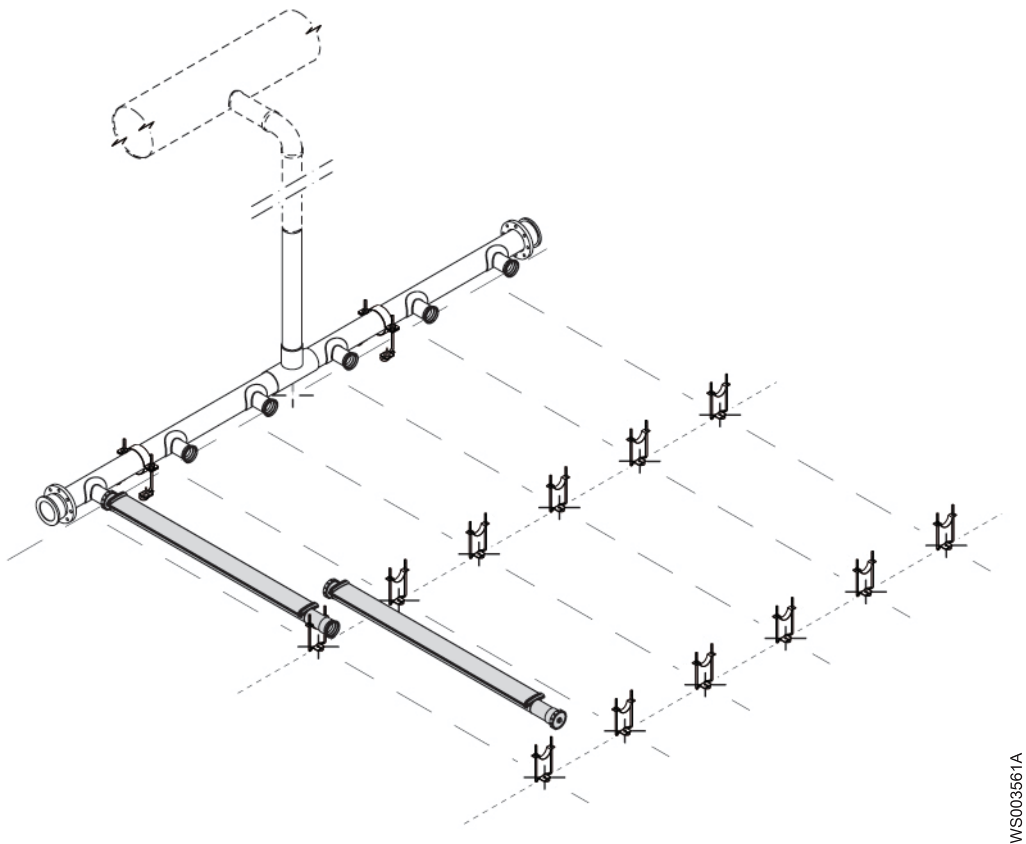
This instruction describes the assembly of a complete air distributor section from the manifold to the end cap.

Use the following:

- Air distributor sections, see the installation drawings and the corresponding markings on the sections
- Spline couplings
- Expansion couplings, if applicable
- Drainline sections, if applicable

Figure 12: Markings on sections

Place the sections



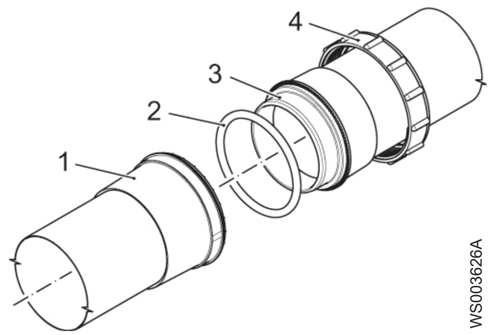
1. Starting from the manifold, check and flush out any dirt from the first section and place it in the supports.
2. Assemble the first section according to the instructions in *Assemble with spline couplings* (page 27).
3. Check and flush out any dirt from the subsequent section and assemble according to the instructions in *Assemble with spline couplings* (page 27) or *Assemble with expansion couplings* (page 28). Repeat this step until all the sections have been assembled.
4. Install the end caps according to the instructions in *Install the end cap* (page 29).

Assemble with spline couplings

Before starting the assembly, ensure that the air distributor sections are as level as possible.

The spline coupling is a coupling that is used to prevent an air distributor section from rotating.

To adjust the spline coupling after the initial installation, it must be loosened and backed off until the splines are disengaged.



1. Spline socket
2. O-ring
3. Spline spigot
4. Retainer ring

Figure 13: Spline coupling

1. Lubricate the O-ring for ease of installation.

   Use a common dish soap solution. Do not use oil or grease.
2. Fit the O-ring into the spline socket.
3. Push the spline spigot into the spline socket.

   Ensure that the splines are fully engaged.
4. Thread the retainer ring onto the spline socket.
5. Tighten the retainer ring to a hand-tight position.

   Do not use a spanner wrench or other tool to tighten the retainer ring. The spanner wrench sent together with spares is used for disassembly only.

Assemble with expansion couplings

Expansion couplings are used in some installations and always together with fixed supports.

1. Spline socket
2. O-ring
3. Retainer ring
4. Spline spigot
5. Retainer ring
6. O-ring

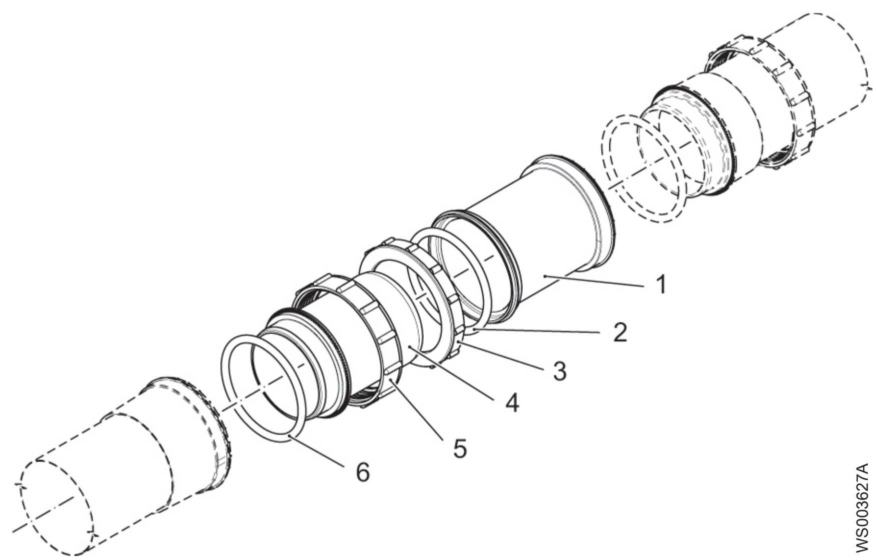
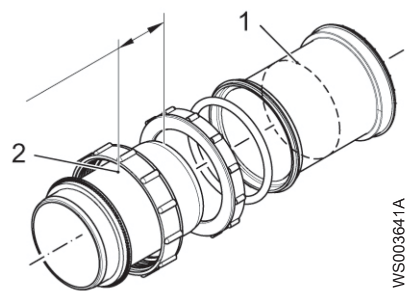


Figure 14: Expansion coupling

1. Assemble the coupling:



1. Spline spigot end placement in an assembled coupling
2. O-ring placement

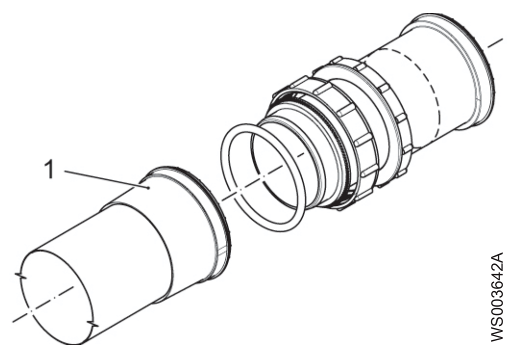
a) Fit both retainer rings on the spline spigot.
b) Lubricate the O-ring for ease of installation.

   Use a common dish soap solution. Do not use oil or grease.
c) Fit the O-ring on the spline spigot.

   Place the O-ring at half the length of the spline spigot, which is 60 mm (2 3/8 in.) from the end.
d) Push the spline socket onto the spline spigot.

   See the exploded view for spline spigot end placement in the spline socket.
e) Thread the retainer ring onto the spline socket, until the O-ring seats.
f) Tighten the retainer ring to a hand-tight position.

2. Install the assembled coupling:



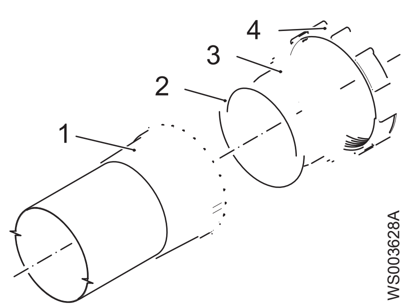
1. Spline socket

a) Lubricate the O-ring for ease of installation.

   Use a common dish soap solution. Do not use oil or grease.
b) Fit the O-ring into the spline socket.
c) Push the assembled coupling into the spline socket.
d) Thread the retainer ring onto the spline socket.
e) Tighten the retainer ring to a hand-tight position.

Install the end cap

The end cap is in some cases factory assembled with the air distributor.

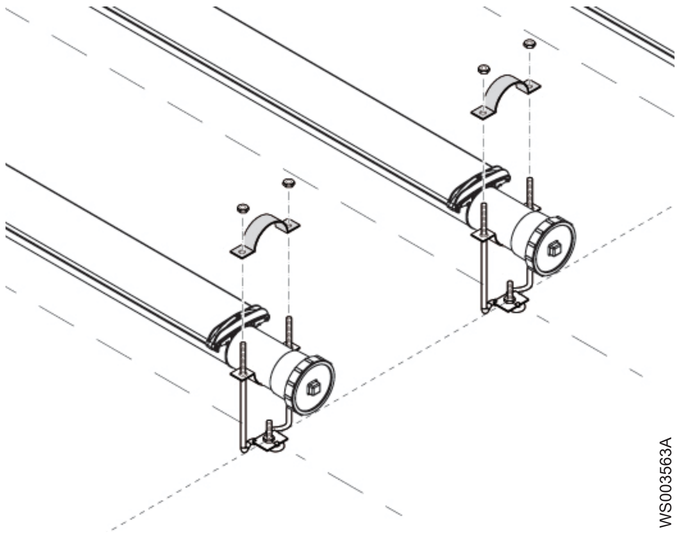


1. Spline socket
2. O-ring
3. End cap
4. Retainer ring

1. Lubricate the O-ring for ease of installation.
   Use a common dish soap solution. Do not use oil or grease.
2. Fit the O-ring into the spline socket.
3. Push the end cap into the spline socket.
4. Thread the retainer ring onto the spline socket.
5. Tighten the retainer ring to a hand-tight position.

Leval and tighten the air distributors

1. Install the top half clamp on each support, and loosely install the top hexagon nuts.



2. Rotate the distributor section until the diffuser is level.
   Use a level system. Make sure to disengage the splines before rotating.
3. Hold the pipe section level and do one or both of the following:
   a) Retighten all corrected spline couplings.
   b) If expansions couplings are used, then tighten all fixed support clamps on those sections.
4. Continue this procedure for all distributor sections.
5. Tighten all nuts on the supports.

NOTICE:
The clamps must be loose around the pipe to allow for movement. Do not wrap anything around the pipe to tighten the clamps against the pipe.

Drainline installation

Separate drainlines are primarily used on fine bubble systems with raised manifolds. On systems with in-line manifolds, the manifold normally serves as drainline.

Ensure that the installation of the drainline is made according to the installation drawings.

Purge system installation

There are two types of purge systems:

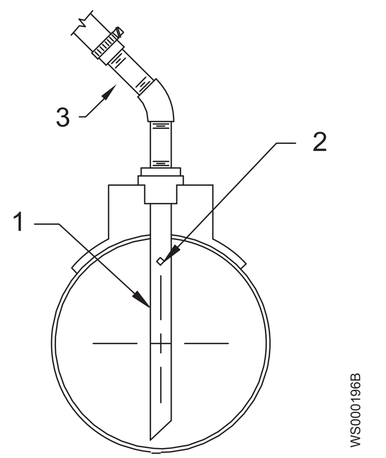
- The manual purge system, with sump and evacuation pipe

  This system uses a sump with an eductor line that extends from the grid to above the water surface and ends with a manual ball valve.
- The continuous purge system, with a diffuser unit that is attached to the bottom of the manifold or the drainline

  The entrapped moisture is continuously purged from the system.

Install a manual purge system

The manual purge system consists of a sump and an evacuation pipe.



1. Suction tube
2. Air orifice hole
3. Evacuation pipe

The sump for systems using in-line manifolds is built into the manifold pipe.

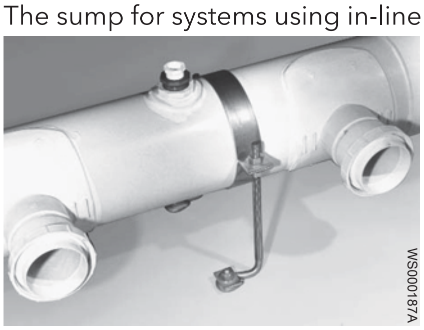
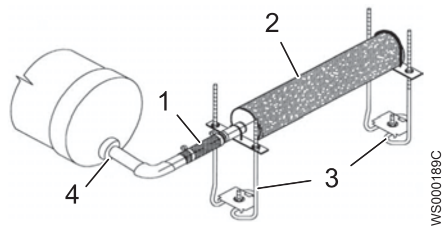


Figure 15: Sump in in-line manifold

1. Identify the parts of the purge system.
2. Install the purge system according to the installation drawings.

Install a continuous purge system

The continuous purge system consists of a diffuser unit that is attached to the bottom of the manifold, air distributor, or drainline.



1. Hose
2. Tube diffuser
3. Support
4. Cap with drainline tap

Figure 16: Continuous purge

The installation is made according to the installation drawings.

1. Assemble the continuous purge.
2. Install the supports on the tank floor according to the installation drawings and the instructions from the anchor bolt manufacturer.

   Ensure that the tube diffuser is placed horizontally, aligned with the orifice and at an elevation lower than the section to which it is attached.
3. Cut the hose to the correct length.
4. Attach the hose to the cap with drainline tap.

   Make sure that the manifold, air distributor, or drainline is tapped at a low point.

Tank storage

Xylem assumes no responsibility for damage and cleaning requirements as a result of long-term storage. See *Application limits* (page 46) for temperature limitations.

- Equipment flooded by overflows, misdirected sewage flows, and excessive airborne dirt build-up require cleaning before being placed in service.
- Standing water which is allowed to freeze around the pipe can break the pipe or cause diffusers to crack.
- UV light degradation and heat build-up in the tank bottom can cause warping and loss of some structural properties.

NOTICE:

Risk of wear. Make sure the equipment is clean before it is placed into service.

Store in tank when air and water is available

This procedure describes storage of an installed system, before taking it into operation.

1. Add protection around the dropleg and the carrier columns in the tank when there is a risk of ice build-up.

   Use for example Styrofoam blocks.
2. Fill the tank with clean water to a minimum level of 1 m (3.1 ft) above the lower droplog. This action gives the pipe and the diffusers protection from UV light and heat build-up.
3. Run a small amount of air through the system to secure that the pipes remain free from water and to minimize the growth of algae on the diffusers.
4. Take appropriate measures against excessive algae growth.
5. Before bringing the system into operation:
   a) Drain and check all hardware.
   b) Check the diffusers and clean if fouling is evident.

The operator may have to adjust the air flow rate to a higher level to prevent ice formation during severely cold temperatures.

Store in tank without air, removed diffusers

This procedure describes storage of an installed system in a flooded tank, before taking it into operation.

1. If there is a risk of ice build up, then start by installing styrofoam blocks around the dropleg and carrier columns installed in the tank.

   If ice builds up around the pipes, these blocks prevent crushing.
2. Remove all diffusers, O-rings, retainer rings, and so on.
3. Clean as required, and store in a clean, dry environment.
4. Fill the tank with clean water to a minumum level of 1 m (3.1 ft) above the lower dropleg.
5. Take appropriate measures against excessive algae growth.
6. Before bringing the system into operation:
   a) Ensure that there is no ice in the tank.
   b) Drain and check all hardware.
   c) Check all holders.
   d) Spot check pipe internals for algae growth and fouling.
   e) Clean as required before installing the diffusers.

NOTICE:
Falling ice can crush the system. If water freezes, do not drain the water below the ice layer.

Store in tank without air, with diffusers

This procedure applies to storing in a flooded tank with diffusers installed.

1. If there is a risk of ice build up, then start by installing styrofoam blocks around the dropleg and carrier columns installed in the tank.

   If ice builds up around the pipes, these blocks prevent crushing.
2. Fill the tank with clean water to a minumum level of 1 m (3.1 ft) above the lower dropleg.
3. Take appropriate measures against excessive algae growth.
4. Before bringing the system into operation:
   a) Ensure that there is no ice in the tank.
   b) Drain and check all hardware.
   c) Spot check pipe internals for algae growth and fouling.
   d) Remove the diffusers and spot check the underside to determine the extent of fouling, and if cleaning is required before use.
   e) Clean as required before use and then remount the diffusers.

NOTICE:
Falling ice can crush the system. If water freezes, do not drain the water below the ice layer.

Operation

Precautions

WARNING:
Always follow safety guidelines when working on the product. See *Introduction and Safety* (page 3).

- Never work alone.
- Make sure that you have a clear path of retreat.
- Never operate the system without safety devices installed.
- Make sure that all safety guards are in place and secure.

Preconditions

Perform a final tank inspection:

- Tighten any loose nuts, joints, or end caps
- Replace any missing or improperly placed hardware.

Before starting the system, ensure that all repair work is completed. Before doing any work, see *Introduction and Safety* (page 3).

Start the system

Complete the start-up procedure before the site visit by authorized service personnel.

WARNING:
- Slips and falls can cause severe injuries.
- Bear in mind the risk of drowning.

NOTICE:
To avoid damage to the piping, introduce water to the tank at a low flow rate and avoid vertical water flow falling directly on the piping.

1. Start filling the aeration tank with clean water.
2. If a manual purge system is installed, then disconnect the purge hoses from the sumps.
3. When the water level reaches a point just above the top of the air distributor pipes, then turn on the air at a low air flux rate of approximately 9 $Nm^3/h/m^2$ (0.5 $SCFM/ft^2$).
4. Check all submerged couplings for air bubbles which indicate leaks.
   Leaking at spline or expansion couplings is normally due to:
   - The O-ring is pinched or out of place.
   - The coupling retainer ring is cross threaded in the spigot.
   - The coupling is not tight.

   Repair as required, see chapter *Maintenance* (page 36).
5. With the air on, check each purge.
   Any water in the pipe should be discharging from the purge.

Condition	Action
There is water in the pipe	The water should be discharging from the purge exit

Condition	Action
There is no water in the pipe	Air should be discharging
Neither air nor water is discharging	Check, and if necessary, clean or redrill the purge air orifice to 5 mm (0.2 in.)

6. Turn the water supply off when it has reached a level of 25 mm (1 in.) below the top of the diffusers.

   This is half way up the retainer ring.

   a) Visually check the level of the aeration system using the water line.

      The distance from the top of the perimeter of the diffusers to the static water level should be ±6 mm (1/4 in.).

   b) Adjust the air distributor sections as required in order to level the aeration system.
7. Check for small leaks in the holders.
8. Increase the air rate to about 18 $Nm^3/h/m^2$ (1 $SCFM/ft^2$) and turn the water supply back on.
9. Fill the aeration tank to a maximum water level of 50–75 mm (2–3 in.) above the diffusers, and then turn off the water.
10. Check all diffuser units for uniform air distribution or excessive air discharge.

    Air should be discharging uniformly across the diffuser surface.

    a) Replace the defective unit if there is excessive air discharge.

11. Reattach the purge hoses to the purge sumps when the system is leak free and is purged of any entrapped water.
12. Leave the tank before filling with more water.
13. Continue filling the tank to a point 1 m (3.1 ft) over the diffusers.
14. Continue to fill with water and check for leaks at the connection between the upper and lower dropleg. Use soapy water.

    Adjust as required.
15. Allow the system to operate 3–4 hours in this mode before introducing the process media (liquid).

Maintenance

Precautions

WARNING:
Always follow safety guidelines when working on the product. See *Introduction and Safety* (page 3).

Requirements

The following requirements apply:

- Never work alone.
- Make sure to have a clear path of retreat.
- Make sure that the work area is properly ventilated.
- Provide a suitable barrier around the work area, for example a guard rail.
- Check the explosion risk before you weld or use electrical hand tools.
- Make sure that the product and its components have been thoroughly cleaned.

The figures in the instructions can differ from the delivered products.

Preventive maintenance

The operator should keep a regular log of pressure and dissolved oxygen readings.

Diffuser fouling is indicated by a continuous increase in:

- Operating pressure
- Air demand without a change in the aeration tank loading
- Air demand with a decrease of dissolved oxygen levels

This chapter includes instructions for:

- Empty the purge system
- Air bumping
- Power failure and loss of air supply
- Visual inspection

Purge the system

Moisture enters the pipe system in the following ways:

- Condensate build-up inside the pipe system due to high blower discharge temperatures, or moist or humid air
- Minor leaks in the pipe system

The effects of entrapped moisture are:

- Increased air velocity and headloss
- Poor air distribution

1. Lower the air flow to the grid for maximum purge results.

   The air velocity is reduced and more of the liquid is forced to the sump.
2. Open the ball valve on the eductor line.

   The trapped liquid is purged from the system.

   CAUTION:
   Contents under pressure. Wear safety goggles.

3. Close the ball valve when the water flow stops and mist appears.

Air bumping

Air bumping is a technique that operators can employ to remove settled debris temporarily on a system in operation, between diffuser cleaning. It means increasing the air flow rate for 5–10 minutes once a week. Use an air rate per diffuser as stated in *Operational limits* (page 46).

Power failure and loss of air supply

The result of a power failure and loss of air supply on membrane diffusers is that solids settle on the diffuser surface. The short-term affect is none.

The long-term effect is that the potential of surface fouling is possible and the diffusers can require a cleaning. This is generally the case for long-term intermittently used membrane diffuser aeration systems (for example Anoxic Zones or Batch Reactors).

Due to the described long-term effect, the operator can be required to shut off adjacent grids or turn on additional blowers to increase the air flow rate and force the membrane off the holder surface.

Visual inspection

Visual inspection is an ongoing preventative maintenance step and can be done while taking routine samples.

- Visually inspect the aeration tank surface pattern.

  The flow should be, for the most part, a nice quiescent pattern. Some coarse bubbling at the tank inlet may occur due to surfactants in the wastewater and is generally dispersed shortly downstream.
- Look for excessive coarse bubbling throughout the tank.

  Coarse bubbling indicates that the diffusers can be fouling.
- Look for large boiling in an isolated area.

  Large boiling indicates a failure in the submerged pipe system or a broken diffuser.

Recurrent maintenance

Maintenance schedule

The following service schedule is recommended to be observed at least once per year.

1. Drain each tank.
2. Remove excess settled solids that have accumulated.
3. Clean diffusers. See *Diffuser cleaning* (page 37).
4. Inspect support hardware to ensure that all components are intact and tight.
5. Inspect spline and expansion coupling retainer rings to make sure that they are tight.

For hardware inspection, see also the corresponding section in the installation chapter, or in other appropriate documentation.

Diffuser cleaning

Clean the diffusers

1. Drain the aeration tank.

The air supply must remain on when the tank is drained and the water is above the diffusers. The valve on the dropleg has to be adjusted as the tank is being drained. Excessive air flow to the tank being drained must be prevented, and enough air must be supplied to adjacent operating grid systems supplied from the same source. Ensure that the air temperature is not exceeding the application limits. See *Application limits* (page 46).

NOTICE:

Excessive heat build-up can damage plastic pipes.

---

2. Clean each diffuser.

   Use a hose with clean water at a nozzle pressure of 410 kPa (60 psig).
3. Scrub each diffuser with a rag or soft bristle brush in order to remove stubborn slime growth, chemical precipitates, or oils.

NOTICE:

Do not use acids or aggressive cleaners on the membranes.

---

4. Inspect the aeration system visually. Ensure that no hardware was loosened or broken during the cleaning.
5. Review and follow the procedure in *Precautions* (page 34) and *Start the system* (page 34).

Manifold repair

Replace a saddle

This section shows how to replace a damaged air distribution connection, a saddle tee, on the manifold. A cracked saddle tee, or a damaged socket end, is hard to detect until the air is turned on. Always replace the entire saddle tee, even if only the socket is damaged.

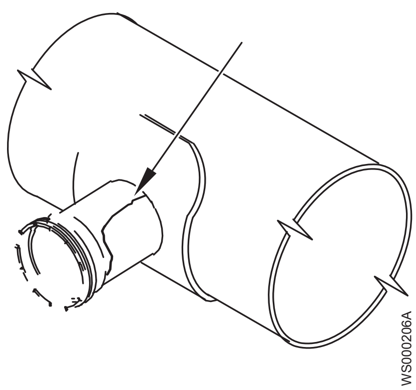


Figure 17: Cracked saddle tee

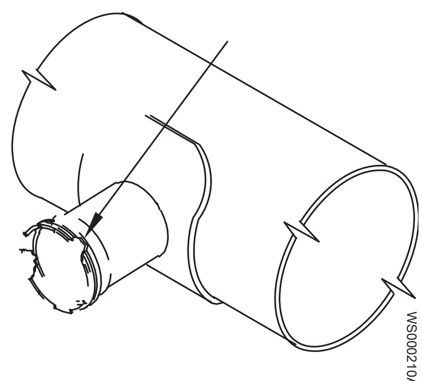
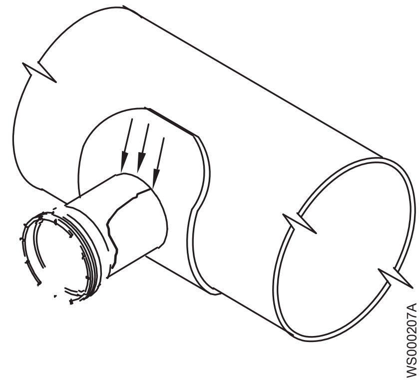


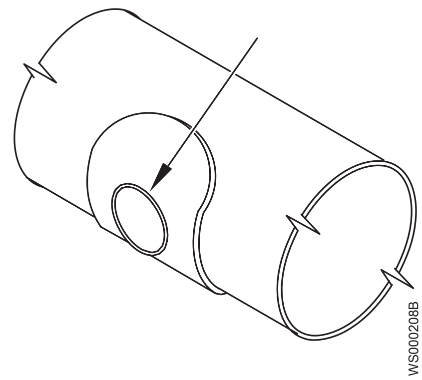
Figure 18: Damaged socket

1. Cut the pipe section off flush with the saddle.

Use a reciprocating type saw (Sawzall).

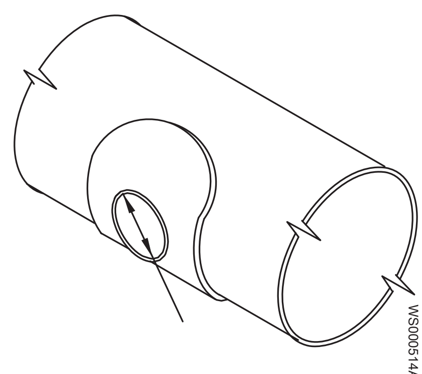


2. Chamfer the inside edge of the saddle opening to remove any saw cut projections.



3. File the saddle opening using a half round file.
4. File off the saddle projection on each side of the opening.

   The clear opening diameter must be 108 mm (4 1/4 in.) for a proper fit of the new saddle piece.



5. Clean and prime the surfaces.
6. Glue the new saddle assembly directly over the existing saddle.

WARNING:

These chemicals can cause physical injury. Contact the supplier for information and advice for proper handling precautions and procedures.

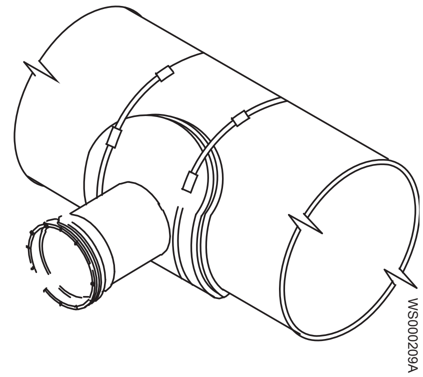


Figure 19: 1-piece saddle tee

7. Secure the saddle assembly to manifold using strap clamps.
8. Allow appropriate time to cure.

Repair a minor leak

This instruction shows how to repair a minor leak around the edge of a saddle tee. Air release at startup indicates a leak.

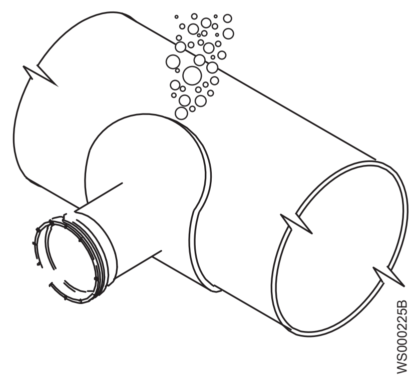


Figure 20: Air release

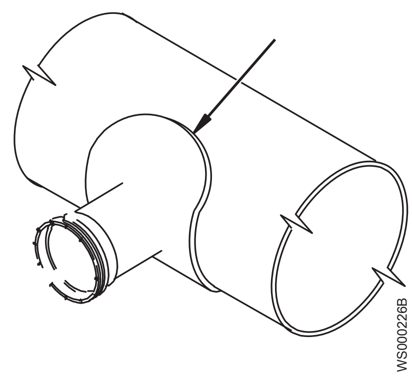


Figure 21: Glue

1. Apply a bead of glue around the edge of the pipe saddle.

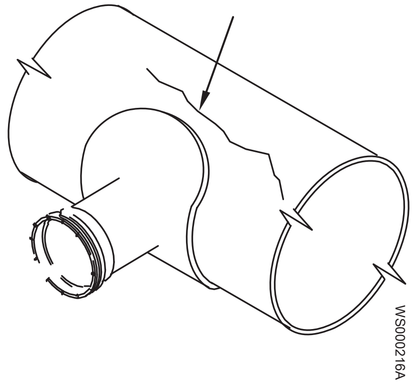
WARNING:

These chemicals can cause physical injury. Contact the supplier for information and advice for proper handling precautions and procedures.

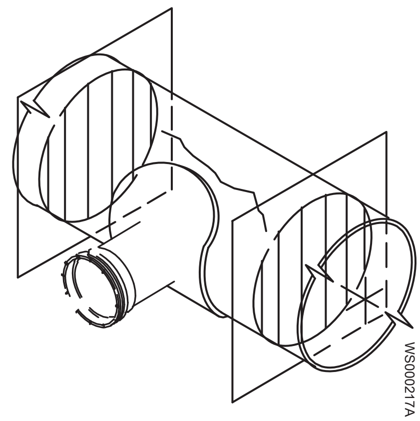
2. Allow adequate time to cure (>24 hours).

Replace a cracked manifold pipe section

This instruction shows how to replace a cracked manifold pipe section. The crack can extend further down the pipe.

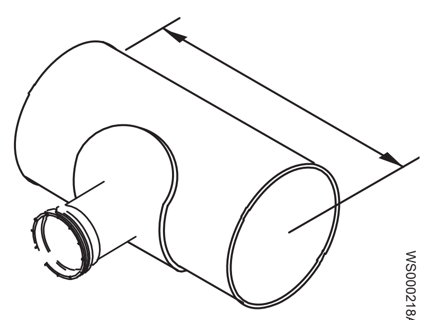


1. Cut the broken pipe section between the saddles.



2. Remove saw cut burrs by filing or sanding the outside edge of the pipe.
3. Cut a length of pipe of the correct diameter and the correct number of tee connections.

   The ends must be cut perpendicular to the pipe.

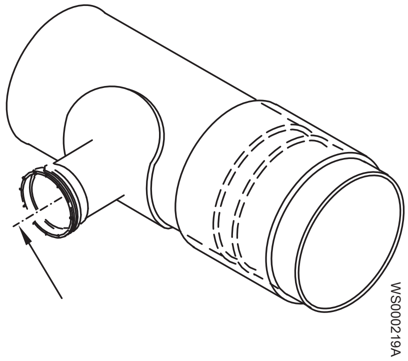


4. Remove the burrs from the cut pipe ends.
5. Glue the repair section to the new couplings.

   Ensure that the couplings are the correct size and type.

WARNING:

These chemicals can cause physical injury. Contact the supplier for information and advice for proper handling precautions and procedures.

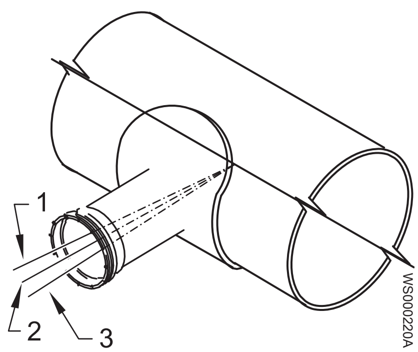


6. Glue the repair section to the original manifold sections.
   Ensure that the manifold air distributor connections are level.

Align an air distributor connection

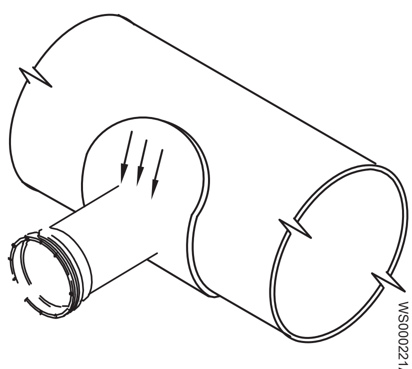
This instruction shows how to align an air distributor connection. Alignment is needed in the following situations:

- The in-line manifold air distributor connection is out of horizontal level, causing the air distributor to be out of level.
- The raised manifold air distributor connection is out of vertical plumb, causing the air distributor to be out of level.



1. Out of level
2. Level
3. Out of level

1. Use a reciprocating type saw (sawzall) and cut the spigot section off flush with the saddle.



2. Follow the instructions in *Replace a saddle* (page 38).

Air distributor repair

Repair a spline coupling

If the spline spigot or spline socket is damaged, then replace the complete diffuser unit. See *Assemble an air distributor section* (page 25).

If the retainer ring in the spline coupling is damaged, then replace it with a replacement retainer ring. See *Replace a spline coupling retainer ring* (page 43)

Replace a spline coupling retainer ring

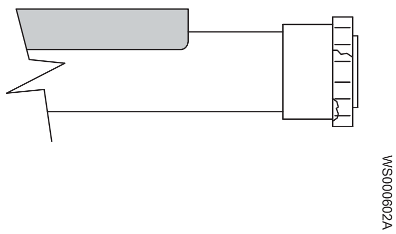


Figure 22: Damaged or broken retainer ring

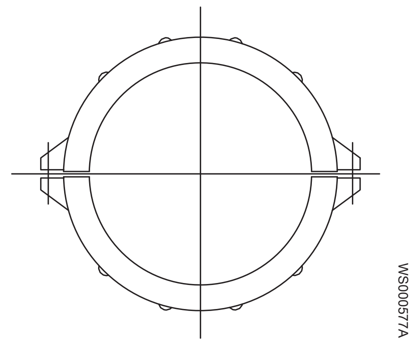


Figure 23: Retainer ring for replacement

1. Cut off the damaged retainer ring.

   Use a hand held hacksaw or pipe saw and be careful not to damage other parts.
2. Install a replacement retainer ring.

Troubleshooting

Operational troubleshooting

For instructions, see chapter *Maintenance* (page 36). For instructions on how to handle other equipment such as air blowers, see the instructions from the manufacturer.

Symptom	Cause	Remedy
Poor air distribution Non-uniform air distribution	Diffusers not level	Level system
	Grid flooded	Operate grid purge system
	Insufficient air	Provide more air
	Solids settling	Provide more air to the grid, perform air bumping procedure, or clean the diffusers
Visible mounding of air in one location	Broken pipe	Repair pipe, see *Manifold repair* (page 38) or*Air distributor repair* (page 43)
Coarse bubbling (large bubbles)	Diffuser fouling, loose coupling, degraded gasket, broken pipe or diffuser	Clean diffusers, see *Diffuser cleaning* (page 37), or inspect and repair accordingly
Low dissolved oxygen (D O) concentration	Too little air	Increase air flow
Increased operating pressure	Diffuser fouling	Clean diffusers, see *Diffuser cleaning* (page 37)
	Line blockage or valve closed	Check air lines and valves
Increased air requirement without load change	Diffuser fouling	Clean diffusers, see *Diffuser cleaning* (page 37)
	Leak in air system	Inspect and repair accordingly

Diffuser fouling

Fine bubble diffusers can foul or become clogged during operation. The rate of fouling, type of foulant, and strength of foulant depend primarily on the constituents in the wastewater.

The results of diffuser fouling include:

- Loss of oxygen transfer efficiency due to bubble coalescence and coarse bubbling
- Increased pressure requirements
- Increased air demand
- Increased operating costs

Several ways to determine if the diffusers are fouled are discussed in *Preventive maintenance* (page 36).

The corrective action for fouled diffusers is to clean them. See *Diffuser cleaning* (page 37).

Diffuser fouling causes

Diffuser fouling is divided into two categories:

- Water side fouling (most common)
- Air side fouling (less common)

Causes of water side fouling include:

- Fibrous material that adheres to the edges of the diffuser units
- Oil or grease in the wastewater

- Precipitated deposits of iron and carbonates
- Biological growths of slime

Causes of air side fouling include:

- Dust and dirt from unfiltered or inadequately filtered air
- Rust and scale from air main corrosion
- Oxidation and subsequent flaking of bituminous air main coatings
- Construction debris
- Mixed liquor solids that enter through system leaks or cracks.

Technical Reference

Application limits

Data	Description
Media (liquid) temperature	• Minimum +2°C (+36°F) • Maximum +38°C (+100°F)
Average pipe temperature, at diffuser	• Minimum –10°C (+14°F) • Maximum +40°C (+104°F)
Average pipe temperature, at lower dropleg	Maximum +55°C (+131°F)

The product is only for use with municipal and industrial wastewater.

Operational limits

Description	Value
AT/AD	• Minimum 2.00 • Maximum 18.00
Depth	• Minimum 1 m (3 ft) • Maximum 12 m (40 ft)
Flux rate	• Minimum 3.66 $Nm^3/h/m^2$ (0.21 $SCFM/ft^2$) • Maximum 36.6 $Nm^3/h/m^2$ (2.15 $SCFM/ft^2$)
Flow per diffuser	Not applicable

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2) A leading global water technology company

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The original instruction is in English. All non-English instructions are translations of the original instruction.

882717_1.0_en.US_2012-03_IOM_Gold_Series

SANITAIRE® Gold Series Installation List

Project	Location	# of Units	Start-Up Date	Contact
Cleveland WWTP	Cleveland, WI – USA	75	December 2010	Steve Simons (920) 693-8236
Nine Springs WWTP	Madison, WI – USA	360	August 2012	Alan Grooms (608) 222-1201
Edmonds WWTP	Edmonds, WA – USA	200	January 2013	Curt Zuvela (425) 771-0237
Cairo WWTP	Cairo, NY - USA	108	April 2013*	Joe Meyers (518) 528-8842
Mogden WWTP	Mogden, UK	4,760	February 2013	Contact Sanitaire
Swinton WWTP	Swinton, UK	525	September 2012	Contact Sanitaire
Zuidhorn WWTP	Zuidhorn, Netherlands	81	May 2010	Contact Sanitaire
Stuttgart University	Stuttgart, Germany	3	September 2011	Contact Sanitaire
Valle Focicchia WWTP	Italy	98	January 2012	Contact Sanitaire
Calco	Italy	336	December 2011	Contact Sanitaire

* Anticipated Start-Up Date

ATTACHMENT E
OTT TUBULAR MEMBRANE PROPOSAL
(OPTION 6)

TAMPA DAR OTT DATA SUMMARY

DAR Zone	Current Ave AOR		Future Ave AOR		Current Max AOR		Future Max AOR		drop size	diffusers
	SCFM/ ZONE	Pressure @ drop	SCFM/ ZONE	Pressure @ drop	SCFM/ ZONE	Pressure @ drop	SCFM/ ZONE	Pressure @ drop		
1	974	7.7	1,536	7.8	1,701	7.9	2,603	8.1	12	264
2	889	7.7	1,347	7.8	1,607	7.9	2,463	8.1	10	240
3	647	7.7	979	7.8	1,341	8.0	2,061	8.1	10	180
4	355	7.7	538	7.8	634	7.9	970	8.1	6	96
5	239	7.7	338	7.8	397	7.9	608	8.1	6	64
6	152	7.7	242	7.8	289	7.9	441	8	4	48
Total/Tank	3,256		4,980		5,969		9,146			892
Total Plant	**13,024**		**19,920**		**23,876**		**36,584**			**3,568**

layout results for OTT membrane tubular diffusers

OTT GROUP

project:	TAMPA DAR	
date:	1/21/2013	
membrane type:	FLEXSIL	
perforation:	fine	
diffuser type:	MAGNUM 2000	

design criteria: *Current average AOR. Zone 1*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:			
	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	166.7 lb O_2/hr	4,000 lb O_2/d
	AOR at 68 °F and 14.7 psia:	155.2 lb O_2/hr	3,726 lb O_2/d
	SOTR	394.59 lb O_2/hr	9,470 lb O_2/d

results:			
	resulting number of diffusers	264 MAGNUM 2000	fine
	resulting standard air flow rate (ASCE):	980 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	997 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	0.57 SCFM/ft	1.73 SCFM/m
	membrane specific air flow rate	1.1 SCFM/ft^2	
	volume specific aeration rate	0.021 SCFM/ft^3 of water	
	volumetric aeration rate	21.7 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.36 SCFM/ft^2 basin surface	
	mixing energy	14.94 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.73 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.50 psi	new diffuser!
	total nominal diffuser length	1,732.4 ft	
	total nominal membrane area	909.4 ft^2	
	diffuser density	33.6 %	
	number of laterals	12	
	diffusers per header	22	
	distance between diffuser axis	13.80 in	
	diffuser grid area	2,148 ft^2	
	Grid Density	79 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	163.9 °F at blower discharge	
	standard oxygen transfer capacity	8.6 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	3.6 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	48.9 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	87.58	
Projected values:			
	SOTE***	38.48 %	2.4 %/ft
	AOTE	21.2 %	1.3 %/ft
	SSOTE***	23.2 g $O_2/m_N^3/m_{id}$	
	AOTE	12.8 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

OTT GROUP

project:	TAMPA DAR
date:	1/21/2013
membrane type:	FLEXSIL
perforation:	fine
diffuser type:	MAGNUM 2000

design criteria: *Current Average AOR. Zone 2*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0	ft
	basin width	52.0	ft
	water volume	46,000	ft^3
	water surface	2,704	ft^2
	basin area	2,704	ft^2
	side water depth	17.0	ft
	submergence of diffuser @ centerline	16.3	ft
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18	lb/ 1,000 ft^3
	oxygen mass%	23.2	%
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44	lb/ 1,000 ft^3
process data:	α factor:	.55	
	β-factor:	0.95	
	DO:	2	mg/l
	TSS:	3000	mg/l
	$T_{wastewater}$:	86.0	°F
	T_{air}:	77	°F
	ambient pressure:	14.7	psia
	actual oxygen transfer rate at 30°C and 14.7 psia:	145.8	lb O_2/hr — 3,500 lb O_2/d
	AOR at 68 °F and 14.7 psia:	135.8	lb O_2/hr — 3,260 lb O_2/d
	SOTR	345.26	lb O_2/hr — 8,286 lb O_2/d
results:	resulting number of diffusers	240	MAGNUM 2000 fine
	resulting standard air flow rate (ASCE):	890	SCFM (@ 68°F, 14.7 psia)
	air required under actual conditions:	905	ACFM (Pamb = 14.7 psia, Tair = 77 °F)
	diffuser thoughput rate	0.56	SCFM/ft — 1.73 SCFM/m
	membrane specific air flow rate	1.1	SCFM/ft^2
	volume specific aeration rate	0.019	SCFM/ft^3 of water
	volumetric aeration rate	19.7	SCFM/1,000 ft^3 of water
	mixing aeration rate	0.33	SCFM/ft^2 basin surface
	mixing energy	13.57	W/m^3 — 4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.73	psig
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.50	psi — new diffuser!
	total nominal diffuser length	1,574.9	ft
	total nominal membrane area	826.7	ft^2
	diffuser density	30.6	%
	number of laterals	12	
	diffusers per header	20	
	distance between diffuser axis	15.25	in
	diffuser grid area	2,148	ft^2
	Grid Density	79	%
	theor. temperature of air @ 68°F influx, 14.7 psia	163.9	°F at blower discharge
	standard oxygen transfer capacity	7.5	lbs/hr/1000 ft^3 water
	oxygen transfer capacity in wastewater	3.2	lbs/hr/1000 ft^3 water
	ESTIMATED BHP	44.4	with 65% blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	79.51	
Projected values:	SOTE***	37.09	% — 2.3 %/ft
	AOTE	20.4	% — 1.2 %/ft
	SSOTE***	22.3	g $O_2/m_N^3/m_{id}$
	AOTE	12.3	g $O_2/m_N^3/m_{id}$

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

OTT GROUP

design criteria: *Current Average AOR. Zone 3*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:			
	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3000 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	104.2 lb O_2/hr	2,500 lb O_2/d
	AOR at 68 °F and 14.7 psia:	97.0 lb O_2/hr	2,329 lb O_2/d
	SOTR	246.62 lb O_2/hr	5,919 lb O_2/d
results:			
	resulting number of diffusers	180 MAGNUM 2000 fine	
	resulting standard air flow rate (ASCE):	647 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	659 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	0.55 SCFM/ft	1.68 SCFM/m
	membrane specific air flow rate	1.0 SCFM/ft^2	
	volume specific aeration rate	0.014 SCFM/ft^3 of water	
	volumetric aeration rate	14.3 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.24 SCFM/ft^2 basin surface	
	mixing energy	9.87 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.73 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.49 psi	new diffuser!
	total nominal diffuser length	1,181.2 ft	
	total nominal membrane area	620.0 ft^2	
	diffuser density	22.9 %	
	number of laterals	12	
	diffusers per header	15	
	distance between diffuser axis	20.69 in	
	diffuser grid area	2,148 ft^2	
	Grid Density	79 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	163.9 °F at blower discharge	
	standard oxygen transfer capacity	5.4 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	2.3 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	32.3 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	57.87	
Projected values:			
	SOTE***	36.40 %	2.2 %/ft
	AOTE	20.0 %	1.2 %/ft
	SSOTE***	21.9 g $O_2/m_N^3/m_{id}$	
	AOTE	12.1 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

OTT GROUP

project:	TAMPA DAR	
date:	1/21/2013	
membrane type:	FLEXSIL	
perforation:	fine	
diffuser type:	MAGNUM 2000	

design criteria: *Current Average AOR. Zone 4*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:			
	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3000 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	52.1 lb O_2/hr	1,250 lb O_2/d
	AOR at 68 °F and 14.7 psia:	48.5 lb O_2/hr	1,164 lb O_2/d
	SOTR	123.28 lb O_2/hr	2,959 lb O_2/d
results:			
	resulting number of diffusers	96 MAGNUM 2000 fine	
	resulting standard air flow rate (ASCE):	355 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	361 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	0.56 SCFM/ft	1.72 SCFM/m
	membrane specific air flow rate	1.1 SCFM/ft^2	
	volume specific aeration rate	0.008 SCFM/ft^3 of water	
	volumetric aeration rate	7.9 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.13 SCFM/ft^2 $_{basin\ surface}$	
	mixing energy	5.42 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.73 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.50 psi	new diffuser!
	total nominal diffuser length	630.0 ft	
	total nominal membrane area	330.7 ft^2	
	diffuser density	12.2 %	
	number of laterals	8	
	diffusers per header	12	
	distance between diffuser axis	26.34 in	
	diffuser grid area	1,432 ft^2	
	Grid Density	53 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	163.9 °F at blower discharge	
	standard oxygen transfer capacity	2.7 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	1.1 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	17.7 with 65% blower efficiency	
	DAILY OPERATING COST @ $0.1/kWh $	31.76	
Projected values:			
	SOTE***	33.16 %	2.0 %/ft
	AOTE	18.2 %	1.1 %/ft
	SSOTE***	20.0 g $O_2/m_N^3/m_{id}$	
	AOTE	11.0 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

OTT GROUP

design criteria: *Current Average AOR. Zone 5*

applied to: *ONE ZONE OF FOUR*

basin data: basin length	52.0 ft	
basin width	52.0 ft	
water volume	46,000 ft^3	
water surface	2,704 ft^2	
basin area	2,704 ft^2	
side water depth	17.0 ft	
submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:		
density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
oxygen mass%	23.2 %	
mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:		
α factor:	.55	
β-factor:	0.95	
DO:	2 mg/l	
TSS:	3000 mg/l	
$T_{wastewater}$:	86.0 °F	
T_{air}:	77 °F	
ambient pressure:	14.7 psia	
actual oxygen transfer rate at 30°C and 14.7 psia:	33.0 lb O_2/hr	792 lb O_2/d
AOR at 68 °F and 14.7 psia:	30.7 lb O_2/hr	738 lb O_2/d
SOTR	78.13 lb O_2/hr	1,875 lb O_2/d
results:		
resulting number of diffusers	64 MAGNUM 2000 fine	
resulting standard air flow rate (ASCE):	239 SCFM (@ 68°F, 14.7 psia)	
air required under actual conditions:	243 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
diffuser thoughput rate	0.57 SCFM/ft	1.74 SCFM/m
membrane specific air flow rate	1.1 SCFM/ft^2	
volume specific aeration rate	0.005 SCFM/ft^3 of water	
volumetric aeration rate	5.3 SCFM/1,000 ft^3 of water	
mixing aeration rate	0.09 SCFM/ft^2 basin surface	
mixing energy	3.64 W/m^3	4 min
min. required system pressure * Includes membrane and grid pressure losses	7.73 psig	
diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.50 psi	new diffuser!
total nominal diffuser length	420.0 ft	
total nominal membrane area	220.5 ft^2	
diffuser density	8.2 %	
number of laterals	8	
diffusers per header	8	
distance between diffuser axis	41.39 in	
diffuser grid area	1,432 ft^2	
Grid Density	53 %	
theor. temperature of air @ 68°F influx, 14.7 psia	163.9 °F at blower discharge	
standard oxygen transfer capacity	1.7 lbs/hr/1000 ft^3 water	
oxygen transfer capacity in wastewater	0.7 lbs/hr/1000 ft^3 water	
ESTIMATED BHP	11.9 with 65% blower efficiency	
DAILY OPERATING COST @ $0.1/kWh $	21.34	
Projected values:		
SOTE***	31.28 %	1.9 %/ft
AOTE	17.2 %	1.1 %/ft
SSOTE***	18.8 g $O_2/m_N^3/m_{id}$	
AOTE	10.4 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

OTT GROUP

design criteria: *Current Average AOR. Zone 6*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:			
	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3000 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	20.8 lb O_2/hr	500 lb O_2/d
	AOR at 68 °F and 14.7 psia:	19.4 lb O_2/hr	466 lb O_2/d
	SOTR	49.32 lb O_2/hr	1,184 lb O_2/d
results:			
	resulting number of diffusers	48 MAGNUM 2000	fine
	resulting standard air flow rate (ASCE):	160 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	163 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	0.51 SCFM/ft	1.56 SCFM/m
	membrane specific air flow rate	1.0 SCFM/ft^2	
	volume specific aeration rate	0.003 SCFM/ft^3 of water	
	volumetric aeration rate	3.5 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.06 SCFM/ft^2 basin surface	
	mixing energy	2.45 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.72 psig	
	diffuser head loss * include additional pressure capacity for cleaning flow rate!	0.49 psi	new diffuser!
	total nominal diffuser length	315.0 ft	
	total nominal membrane area	165.3 ft^2	
	diffuser density	6.1 %	
	number of laterals	8	
	diffusers per header	6	
	distance between diffuser axis	57.95 in	
	diffuser grid area	1,432 ft^2	
	Grid Density	53 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	163.8 °F at blower discharge	
	standard oxygen transfer capacity	1.1 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	0.5 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	8.0 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	14.31	
Projected values:			
	SOTE***	29.40 %	1.8 %/ft
	AOTE	16.2 %	1.0 %/ft
	SSOTE***	17.7 g $O_2/m_N^3/m_{id}$	
	AOTE	9.7 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

OTT GROUP

design criteria: *Current Maximum AOR. Zone 1*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:	α factor:	.55	
	β-factor:	0.95	
	DO:	1 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	300.0 lb O_2/hr	7,200 lb O_2/d
	AOR at 68 °F and 14.7 psia:	282.1 lb O_2/hr	6,772 lb O_2/d
	SOTR	616.37 lb O_2/hr	14,793 lb O_2/d
results:	resulting number of diffusers	264 MAGNUM 2000	fine
	resulting standard air flow rate (ASCE):	1,701 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	1,730 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	0.98 SCFM/ft	3.00 SCFM/m
	membrane specific air flow rate	1.9 SCFM/ft^2	
	volume specific aeration rate	0.037 SCFM/ft^3 of water	
	volumetric aeration rate	37.6 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.63 SCFM/ft^2 basin surface	
	mixing energy	25.93 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.92 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.58 psi	new diffuser!
	total nominal diffuser length	1,732.4 ft	
	total nominal membrane area	909.4 ft^2	
	diffuser density	33.6 %	
	number of laterals	12	
	diffusers per header	22	
	distance between diffuser axis	13.80 in	
	diffuser grid area	2,148 ft^2	
	Grid Density	79 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	166.3 °F at blower discharge	
	standard oxygen transfer capacity	13.4 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	6.5 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	86.5 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh	$ 154.79	
Projected values:	SOTE***	34.64 %	2.1 %/ft
	AOTE	19.1 %	1.2 %/ft
	SSOTE***	20.9 g $O_2/m_N^3/m_{id}$	
	AOTE	11.5 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project:	TAMPA DAR
date:	1/21/2013
membrane type:	FLEXSIL
perforation:	fine
diffuser type:	MAGNUM 2000

	design criteria:	*Current Maximum AOR. Zone 2*	
	applied to:	*ONE ZONE OF FOUR*	
basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:	α factor:	.55	
	β-factor:	0.95	
	DO:	1 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	68.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 20°C and 14.7 psia:	262.5 lb O_2/hr	6,300 lb O_2/d
	AOR at 68 °F and 14.7 psia:	262.5 lb O_2/hr	6,300 lb O_2/d
	SOTR	556.93 lb O_2/hr	13,366 lb O_2/d
results:	resulting number of diffusers	240 MAGNUM 2000 fine	
	resulting standard air flow rate (ASCE):	1,607 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	1,635 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	1.02 SCFM/ft	3.12 SCFM/m
	membrane specific air flow rate	1.9 SCFM/ft^2	
	volume specific aeration rate	0.035 SCFM/ft^3 of water	
	volumetric aeration rate	35.5 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.59 SCFM/ft^2 basin surface	
	mixing energy	24.51 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.92 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.59 psi	new diffuser!
	total nominal diffuser length	1,574.9 ft	
	total nominal membrane area	826.7 ft^2	
	diffuser density	30.6 %	
	number of laterals	12	
	diffusers per header	20	
	distance between diffuser axis	15.25 in	
	diffuser grid area	2,148 ft^2	
	Grid Density	79 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	166.3 °F at blower discharge	
	standard oxygen transfer capacity	12.1 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	5.7 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	81.7 with 65% blower efficiency	
	DAILY OPERATING COST @ $0.1/kWh	$ 146.29	
Projected values:	SOTE***	33.11 %	2.0 %/ft
	AOTE	18.2 %	1.1 %/ft
	SSOTE***	19.9 g $O_2/m_N^3/m_{id}$	
	AOTE	11.0 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

OTT GROUP

project:	TAMPA DAR
date:	1/21/2013
membrane type:	FLEXSIL
perforation:	fine
diffuser type:	MAGNUM 2000

design criteria: *Future Maximum AOR. Zone 3*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3000 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	187.5 lb O_2/hr	4,500 lb O_2/d
	AOR at 68 °F and 14.7 psia:	174.6 lb O_2/hr	4,191 lb O_2/d
	SOTR	443.91 lb O_2/hr	10,654 lb O_2/d
results:	resulting number of diffusers	180 MAGNUM 2000 fine	
	resulting standard air flow rate (ASCE):	1,341 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	1,365 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	1.14 SCFM/ft	3.47 SCFM/m
	membrane specific air flow rate	2.2 SCFM/ft^2	
	volume specific aeration rate	0.029 SCFM/ft^3 of water	
	volumetric aeration rate	29.7 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.50 SCFM/ft^2 basin surface	
	mixing energy	20.46 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.95 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.61 psi	new diffuser!
	total nominal diffuser length	1,181.2 ft	
	total nominal membrane area	620.0 ft^2	
	diffuser density	22.9 %	
	number of laterals	12	
	diffusers per header	15	
	distance between diffuser axis	20.69 in	
	diffuser grid area	2,148 ft^2	
	Grid Density	79 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	166.6 °F at blower discharge	
	standard oxygen transfer capacity	9.7 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	4.1 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	68.4 with 65% blower efficiency	
	DAILY OPERATING COST @ $0.1/kWh $	122.44	
Projected values:	SOTE***	31.62 %	1.9 %/ft
	AOTE	17.4 %	1.1 %/ft
	SSOTE***	19.1 g $O_2/m_N^3/m_{id}$	
	AOTE	10.5 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

OTT GROUP

design criteria: *Current Maximum AOR. Zone 4*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:			
	α factor:	.55	
	β-factor:	0.95	
	DO:	1 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	68.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 20°C and 14.7 psia:	93.7 lb O_2/hr	2,250 lb O_2/d
	AOR at 68 °F and 14.7 psia:	93.7 lb O_2/hr	2,250 lb O_2/d
	SOTR	198.88 lb O_2/hr	4,773 lb O_2/d
results:			
	resulting number of diffusers	96 MAGNUM 2000 fine	
	resulting standard air flow rate (ASCE):	634 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	644 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	1.01 SCFM/ft	3.07 SCFM/m
	membrane specific air flow rate	1.9 SCFM/ft^2	
	volume specific aeration rate	0.014 SCFM/ft^3 of water	
	volumetric aeration rate	14.0 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.23 SCFM/ft^2 basin surface	
	mixing energy	9.66 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.92 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.58 psi	new diffuser!
	total nominal diffuser length	630.0 ft	
	total nominal membrane area	330.7 ft^2	
	diffuser density	12.2 %	
	number of laterals	8	
	diffusers per header	12	
	distance between diffuser axis	26.34 in	
	diffuser grid area	1,432 ft^2	
	Grid Density	53 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	166.3 °F at blower discharge	
	standard oxygen transfer capacity	4.3 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	2.0 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	32.2 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	57.67	
Projected values:			
	SOTE***	30.00 %	1.8 %/ft
	AOTE	16.5 %	1.0 %/ft
	SSOTE***	18.1 g $O_2/m_N^3/m_{id}$	
	AOTE	9.9 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

OTT GROUP

design criteria: ***Current Maximum AOR. Zone 5***

applied to: ***ONE ZONE OF FOUR***

basin data:	**basin length**	**52.0 ft**	
	basin width	**52.0 ft**	
	water volume	**46,000 ft^3**	
	water surface	**2,704 ft^2**	
	basin area	**2,704 ft^2**	
	side water depth	**17.0 ft**	
	submergence of diffuser @ centerline	**16.3 ft**	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:	**α factor:**	**.55**	
	β-factor:	0.95	
	DO:	1 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	68.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 20°C and 14.7 psia:	**56.2 lb O_2/hr**	**1,350 lb O_2/d**
	AOR at 68 °F and 14.7 psia:	**56.2 lb O_2/hr**	**1,350 lb O_2/d**
	SOTR	**119.32 lb O_2/hr**	**2,864 lb O_2/d**
results:			
	resulting number of diffusers	**64 MAGNUM 2000**	**fine**
	resulting standard air flow rate (ASCE):	**397 SCFM (@ 68°F, 14.7 psia)**	
	air required under actual conditions:	**404 ACFM (Pamb = 14.7 psia, Tair = 77 °F)**	
	diffuser thoughput rate	**0.95 SCFM/ft**	**2.89 SCFM/m**
	membrane specific air flow rate	**1.8 SCFM/ft^2**	
	volume specific aeration rate	**0.009 SCFM/ft^3 of water**	
	volumetric aeration rate	**8.8 SCFM/1,000 ft^3 of water**	
	mixing aeration rate	**0.15 SCFM/ft^2 basin surface**	
	mixing energy	**6.06 W/m^3**	**4 min**
	min. required system pressure	**7.91 psig**	
	* Includes membrane and grid pressure losses		
	diffuser head loss	**0.57 psi**	**new diffuser!**
	*** Include additional pressure capacity for cleaning flow rate!**		
	total nominal diffuser length	**420.0 ft**	
	total nominal membrane area	**220.5 ft^2**	
	diffuser density	**8.2 %**	
	number of laterals	**8**	
	diffusers per header	**8**	
	distance between diffuser axis	**41.39 in**	
	diffuser grid area	**1,432 ft^2**	
	Grid Density	**53 %**	
	theor. temperature of air @ 68°F influx, 14.7 psia	**166.1 °F at blower discharge**	
	standard oxygen transfer capacity	**2.6 lbs/hr/1000 ft^3 water**	
	oxygen transfer capacity in wastewater	**1.2 lbs/hr/1000 ft^3 water**	
	ESTIMATED BHP	**20.2 with 65%**	**blower efficiency**
	DAILY OPERATING COST @ $0.1/kWh $	**36.13**	
Projected values:			
	SOTE***	**28.69 %**	**1.8 %/ft**
	AOTE	**15.8 %**	**1.0 %/ft**
	SSOTE***	**17.3 g $O_2/m_N^3/m_{id}$**	
	AOTE	**9.5 g $O_2/m_N^3/m_{id}$**	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project:	TAMPA DAR
date:	1/21/2013
membrane type:	FLEXSIL
perforation:	fine
diffuser type:	MAGNUM 2000

design criteria: *Future Maximum AOR. Zone 6*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:	α factor:	.55	
	β-factor:	0.95	
	DO:	1 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	68.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 20°C and 14.7 psia:	37.5 lb O_2/hr	900 lb O_2/d
	AOR at 68 °F and 14.7 psia:	37.5 lb O_2/hr	900 lb O_2/d
	SOTR	79.56 lb O_2/hr	1,909 lb O_2/d
results:	resulting number of diffusers	48 MAGNUM 2000	fine
	resulting standard air flow rate (ASCE):	289 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	294 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	0.92 SCFM/ft	2.80 SCFM/m
	membrane specific air flow rate	1.7 SCFM/ft^2	
	volume specific aeration rate	0.006 SCFM/ft^3 of water	
	volumetric aeration rate	6.4 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.11 SCFM/ft^2 basin surface	
	mixing energy	4.41 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.91 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.56 psi	new diffuser!
	total nominal diffuser length	315.0 ft	
	total nominal membrane area	165.3 ft^2	
	diffuser density	6.1 %	
	number of laterals	8	
	diffusers per header	6	
	distance between diffuser axis	57.95 in	
	diffuser grid area	1,432 ft^2	
	Grid Density	53 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	166.1 °F at blower discharge	
	standard oxygen transfer capacity	1.7 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	0.8 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	14.7 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	26.26	
Projected values:	SOTE***	26.32 %	1.6 %/ft
	AOTE	14.5 %	0.9 %/ft
	SSOTE***	15.9 g $O_2/m_N^3/m_{id}$	
	AOTE	8.7 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project:	TAMPA DAR
date:	1/21/2013
membrane type:	FLEXSIL
perforation:	fine
diffuser type:	MAGNUM 2000

design criteria: *Future Average AOR. Zone 1*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	239.9 lb O_2/hr	5,759 lb O_2/d
	AOR at 68 °F and 14.7 psia:	223.5 lb O_2/hr	5,364 lb O_2/d
	SOTR	568.08 lb O_2/hr	13,634 lb O_2/d
results:	resulting number of diffusers	264 MAGNUM 2000 fine	
	resulting standard air flow rate (ASCE):	1,536 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	1,562 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	0.89 SCFM/ft	2.71 SCFM/m
	membrane specific air flow rate	1.7 SCFM/ft^2	
	volume specific aeration rate	0.033 SCFM/ft^3 of water	
	volumetric aeration rate	34.0 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.57 SCFM/ft^2 basin surface	
	mixing energy	23.42 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.84 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.56 psi	new diffuser!
	total nominal diffuser length	1,732.4 ft	
	total nominal membrane area	909.4 ft^2	
	diffuser density	33.6 %	
	number of laterals	12	
	diffusers per header	22	
	distance between diffuser axis	13.80 in	
	diffuser grid area	2,148 ft^2	
	Grid Density	79 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	165.2 °F at blower discharge	
	standard oxygen transfer capacity	12.3 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	5.2 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	77.4 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	138.63	
Projected values:	SOTE***	35.35 %	2.2 %/ft
	AOTE	19.4 %	1.2 %/ft
	SSOTE***	21.3 g $O_2/m_N^3/m_{id}$	
	AOTE	11.7 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

OTT GROUP

project:	TAMPA DAR
date:	1/21/2013
membrane type:	FLEXSIL
perforation:	fine
diffuser type:	MAGNUM 2000

design criteria: *Future Average AOR. Zone 2*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:			
	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3000 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	204.2 lb O_2/hr	4,900 lb O_2/d
	AOR at 68 °F and 14.7 psia:	190.2 lb O_2/hr	4,564 lb O_2/d
	SOTR	483.37 lb O_2/hr	11,601 lb O_2/d
results:			
	resulting number of diffusers	240 MAGNUM 2000	fine
	resulting standard air flow rate (ASCE):	1,347 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	1,370 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	0.86 SCFM/ft	2.61 SCFM/m
	membrane specific air flow rate	1.6 SCFM/ft^2	
	volume specific aeration rate	0.029 SCFM/ft^3 of water	
	volumetric aeration rate	29.8 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.50 SCFM/ft^2 basin surface	
	mixing energy	20.54 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.84 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.55 psi	new diffuser!
	total nominal diffuser length	1,574.9 ft	
	total nominal membrane area	826.7 ft^2	
	diffuser density	30.6 %	
	number of laterals	12	
	diffusers per header	20	
	distance between diffuser axis	15.25 in	
	diffuser grid area	2,148 ft^2	
	Grid Density	79 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	165.2 °F at blower discharge	
	standard oxygen transfer capacity	10.5 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	4.4 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	67.9 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh	$ 121.55	
Projected values:			
	SOTE***	34.30 %	2.1 %/ft
	AOTE	18.9 %	1.2 %/ft
	SSOTE***	20.7 g $O_2/m_N^3/m_{id}$	
	AOTE	11.4 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

OTT GROUP

design criteria: *Future Average AOR. Zone 3*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3000 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	145.8 lb O_2/hr	3,500 lb O_2/d
	AOR at 68 °F and 14.7 psia:	135.8 lb O_2/hr	3,260 lb O_2/d
	SOTR	345.26 lb O_2/hr	8,286 lb O_2/d

results:			
	resulting number of diffusers	180 MAGNUM 2000	fine
	resulting standard air flow rate (ASCE):	979 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	996 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	0.83 SCFM/ft	2.53 SCFM/m
	membrane specific air flow rate	1.6 SCFM/ft^2	
	volume specific aeration rate	0.021 SCFM/ft^3 of water	
	volumetric aeration rate	21.7 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.36 SCFM/$ft^2_{\text{basin surface}}$	
	mixing energy	14.94 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.82 psig	
	diffuser head loss * include additional pressure capacity for cleaning flow rate!	0.55 psi	new diffuser!
	total nominal diffuser length	1,181.2 ft	
	total nominal membrane area	620.0 ft^2	
	diffuser density	22.9 %	
	number of laterals	12	
	diffusers per header	15	
	distance between diffuser axis	20.69 in	
	diffuser grid area	2,148 ft^2	
	Grid Density	79 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	165.0 °F at blower discharge	
	standard oxygen transfer capacity	7.5 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	3.2 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	49.3 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	88.29	

Projected values:			
	SOTE***	33.69 %	2.1 %/ft
	AOTE	18.5 %	1.1 %/ft
	SSOTE***	20.3 g $O_2/m_N^3/m_{id}$	
	AOTE	11.2 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

OTT GROUP

design criteria: *Future Average AOR. Zone 4*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3000 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	72.9 lb O_2/hr	1,750 lb O_2/d
	AOR at 68 °F and 14.7 psia:	67.9 lb O_2/hr	1,630 lb O_2/d
	SOTR	172.60 lb O_2/hr	4,143 lb O_2/d
results:	resulting number of diffusers	96 MAGNUM 2000	fine
	resulting standard air flow rate (ASCE):	538 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	547 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	0.85 SCFM/ft	2.61 SCFM/m
	membrane specific air flow rate	1.6 SCFM/ft^2	
	volume specific aeration rate	0.012 SCFM/ft^3 of water	
	volumetric aeration rate	11.9 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.20 SCFM/ft^2 basin surface	
	mixing energy	8.20 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	7.84 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.55 psi	new diffuser!
	total nominal diffuser length	630.0 ft	
	total nominal membrane area	330.7 ft^2	
	diffuser density	12.2 %	
	number of laterals	8	
	diffusers per header	12	
	distance between diffuser axis	26.34 in	
	diffuser grid area	1,432 ft^2	
	Grid Density	53 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	165.2 °F at blower discharge	
	standard oxygen transfer capacity	3.8 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	1.6 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	27.1 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	48.55	
Projected values:	SOTE***	30.67 %	1.9 %/ft
	AOTE	16.9 %	1.0 %/ft
	SSOTE***	18.5 g $O_2/m_N^3/m_{id}$	
	AOTE	10.2 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

OTT GROUP

design criteria: *Current Average AOR. Zone 5*

applied to: *ONE ZONE OF FOUR*

basin data: basin length	52.0	ft	
basin width	52.0	ft	
water volume	46,000	ft^3	
water surface	2,704	ft^2	
basin area	2,704	ft^2	
side water depth	17.0	ft	
submergence of diffuser @ centerline	16.3	ft	
state of air: standard conditions in accordance with ASCE standards:			
density of air @ 68°F, 14.7 psia	75.18	lb/ 1,000 ft^3	
oxygen mass%	23.2	%	
mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44	lb/ 1,000 ft^3	
process data: α factor:	.55		
β-factor:	0.95		
DO:	2	mg/l	
TSS:	3000	mg/l	
$T_{wastewater}$:	86.0	°F	
T_{air}:	77	°F	
ambient pressure:	14.7	psia	
actual oxygen transfer rate at 30°C and 14.7 psia:	43.7	lb O_2/hr	1,050 lb O_2/d
AOR at 68 °F and 14.7 psia:	40.7	lb O_2/hr	978 lb O_2/d
SOTR	103.55	lb O_2/hr	2,485 lb O_2/d
results: resulting number of diffusers	64	MAGNUM 2000	fine
resulting standard air flow rate (ASCE):	338	SCFM (@ 68°F, 14.7 psia)	
air required under actual conditions:	343	ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
diffuser thoughput rate	0.80	SCFM/ft	2.46 SCFM/m
membrane specific air flow rate	1.5	SCFM/ft^2	
volume specific aeration rate	0.007	SCFM/ft^3 of water	
volumetric aeration rate	7.5	SCFM/1,000 ft^3 of water	
mixing aeration rate	0.12	SCFM/ft^2 basin surface	
mixing energy	5.15	W/m^3	4 min
min. required system pressure * Includes membrane and grid pressure losses	7.82	psig	
diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.54	psi	new diffuser!
total nominal diffuser length	420.0	ft	
total nominal membrane area	220.5	ft^2	
diffuser density	8.2	%	
number of laterals	8		
diffusers per header	8		
distance between diffuser axis	41.39	in	
diffuser grid area	1,432	ft^2	
Grid Density	53	%	
theor. temperature of air @ 68°F influx, 14.7 psia	165.0	°F at blower discharge	
standard oxygen transfer capacity	2.3	lbs/hr/1000 ft^3 water	
oxygen transfer capacity in wastewater	1.0	lbs/hr/1000 ft^3 water	
ESTIMATED BHP	17.0	with 65%	blower efficiency
DAILY OPERATING COST @ $0.1/kWh $	30.43		
Projected values: SOTE***	29.31	%	1.8 %/ft
AOTE	16.1	%	1.0 %/ft
SSOTE***	17.7	g $O_2/m_N^3/m_{id}$	
AOTE	9.7	g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

OTT GROUP

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

design criteria: *Current Average AOR. Zone 6*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft
	basin width	52.0 ft
	water volume	46,000 ft^3
	water surface	2,704 ft^2
	basin area	2,704 ft^2
	side water depth	17.0 ft
	submergence of diffuser @ centerline	16.3 ft
state of air: standard conditions in accordance with ASCE standards:		
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3
	oxygen mass%	23.2 %
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3

process data:			
	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3000 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	29.2 lb O_2/hr	700 lb O_2/d
	AOR at 68 °F and 14.7 psia:	27.2 lb O_2/hr	652 lb O_2/d
	SOTR	69.05 lb O_2/hr	1,657 lb O_2/d

results:					
	resulting number of diffusers	48	MAGNUM 2000	fine	
	resulting standard air flow rate (ASCE):	242	SCFM (@ 68°F, 14.7 psia)		
	air required under actual conditions:	246	ACFM (Pamb = 14.7 psia, Tair = 77 °F)		
	diffuser thoughput rate	0.77	SCFM/ft	2.35 SCFM/m	
	membrane specific air flow rate	1.5	SCFM/ft^2		
	volume specific aeration rate	0.005	SCFM/ft^3 of water		
	volumetric aeration rate	5.4	SCFM/1,000 ft^3 of water		
	mixing aeration rate	0.09	SCFM/ft^2 basin surface		
	mixing energy	3.69	W/m^3	4 min	
	min. required system pressure * Includes membrane and grid pressure losses	7.81	psig		
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.53	psi	new diffuser!	
	total nominal diffuser length	315.0	ft		
	total nominal membrane area	165.3	ft^2		
	diffuser density	6.1	%		
	number of laterals	8			
	diffusers per header	6			
	distance between diffuser axis	57.95	in		
	diffuser grid area	1,432	ft^2		
	Grid Density	53	%		
	theor. temperature of air @ 68°F influx, 14.7 psia	164.8	°F at blower discharge		
	standard oxygen transfer capacity	1.5	lbs/hr/1000 ft^3 water		
	oxygen transfer capacity in wastewater	0.6	lbs/hr/1000 ft^3 water		
	ESTIMATED BHP	12.2	with	65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	21.81			

Projected values:			
	SOTE***	27.24 %	1.7 %/ft
	AOTE	15.0 %	0.9 %/ft
	SSOTE***	16.4 g $O_2/m_N^3/m_{id}$	
	AOTE	9.0 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

OTT GROUP

project:	TAMPA DAR
date:	1/21/2013
membrane type:	FLEXSIL
perforation:	fine
diffuser type:	MAGNUM 2000

design criteria: *Future Maximum AOR. Zone 1*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:			
	α factor:	.55	
	β-factor:	0.95	
	DO:	1 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	420.0 lb O_2/hr	10,080 lb O_2/d
	AOR at 68 °F and 14.7 psia:	395.0 lb O_2/hr	9,480 lb O_2/d
	SOTR	862.91 lb O_2/hr	20,710 lb O_2/d
results:			
	resulting number of diffusers	264 MAGNUM 2000 fine	
	resulting standard air flow rate (ASCE):	2,604 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	2,649 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	1.50 SCFM/ft	4.60 SCFM/m
	membrane specific air flow rate	2.9 SCFM/ft^2	
	volume specific aeration rate	0.057 SCFM/ft^3 of water	
	volumetric aeration rate	57.6 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.96 SCFM/ft^2 basin surface	
	mixing energy	39.71 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	8.08 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.70 psi	new diffuser!
	total nominal diffuser length	1,732.4 ft	
	total nominal membrane area	909.4 ft^2	
	diffuser density	33.6 %	
	number of laterals	12	
	diffusers per header	22	
	distance between diffuser axis	13.80 in	
	diffuser grid area	2,148 ft^2	
	Grid Density	79 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	168.3 °F at blower discharge	
	standard oxygen transfer capacity	18.8 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	9.1 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	134.4 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	240.63	
Projected values:			
	SOTE***	31.67 %	1.9 %/ft
	AOTE	17.4 %	1.1 %/ft
	SSOTE***	19.1 g $O_2/m_N^3/m_{id}$	
	AOTE	10.5 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project:	TAMPA DAR
date:	1/21/2013
membrane type:	FLEXSIL
perforation:	fine
diffuser type:	MAGNUM 2000

design criteria: *Future Maximum AOR. Zone 2*

applied to: *ONE ZONE OF FOUR*

basin data: basin length	52.0	ft	
basin width	52.0	ft	
water volume	46,000	ft^3	
water surface	2,704	ft^2	
basin area	2,704	ft^2	
side water depth	17.0	ft	
submergence of diffuser @ centerline	16.3	ft	
state of air: standard conditions in accordance with ASCE standards:			
density of air @ 68°F, 14.7 psia	75.18	lb/ 1,000 ft^3	
oxygen mass%	23.2	%	
mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44	lb/ 1,000 ft^3	
process data:			
α factor:	.55		
β-factor:	0.95		
DO:	1	mg/l	
TSS:	3500	mg/l	
$T_{wastewater}$:	68.0	°F	
T_{air}:	77	°F	
ambient pressure:	14.7	psia	
actual oxygen transfer rate at 20°C and 14.7 psia:	367.5	lb O_2/hr	8,820 lb O_2/d
AOR at 68 °F and 14.7 psia:	367.5	lb O_2/hr	8,820 lb O_2/d
SOTR	779.72	lb O_2/hr	18,713 lb O_2/d
results:			
resulting number of diffusers	240	MAGNUM 2000	fine
resulting standard air flow rate (ASCE):	2,464	SCFM (@ 68°F, 14.7 psia)	
air required under actual conditions:	2,506	ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
diffuser thoughput rate	1.56	SCFM/ft	4.78 SCFM/m
membrane specific air flow rate	3.0	SCFM/ft^2	
volume specific aeration rate	0.054	SCFM/ft^3 of water	
volumetric aeration rate	54.5	SCFM/1,000 ft^3 of water	
mixing aeration rate	0.91	SCFM/ft^2 basin surface	
mixing energy	37.57	W/m^3	4 min
min. required system pressure * Includes membrane and grid pressure losses	8.10	psig	
diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.71	psi	new diffuser!
total nominal diffuser length	1,574.9	ft	
total nominal membrane area	826.7	ft^2	
diffuser density	30.6	%	
number of laterals	12		
diffusers per header	20		
distance between diffuser axis	15.25	in	
diffuser grid area	2,148	ft^2	
Grid Density	79	%	
theor. temperature of air @ 68°F influx, 14.7 psia	168.4	°F at blower discharge	
standard oxygen transfer capacity	17.0	lbs/hr/1000 ft^3 water	
oxygen transfer capacity in wastewater	8.0	lbs/hr/1000 ft^3 water	
ESTIMATED BHP	127.3	with 65%	blower efficiency
DAILY OPERATING COST @ $0.1/kWh $	227.96		
Projected values:			
SOTE***	30.24	%	1.9 %/ft
AOTE	16.6	%	1.0 %/ft
SSOTE***	18.2	g $O_2/m_N^3/m_{id}$	
AOTE	10.0	g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: **TAMPA DAR**
date: **1/21/2013**
membrane type: **FLEXSIL**
perforation: **fine**
diffuser type: **MAGNUM 2000**

OTT GROUP

design criteria: ***Future Maximum AOR. Zone 3***

applied to: ***ONE ZONE OF FOUR***

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:			
	α factor:	.55	
	β-factor:	0.95	
	DO:	2 mg/l	
	TSS:	3000 mg/l	
	$T_{wastewater}$:	86.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 30°C and 14.7 psia:	262.5 lb O_2/hr	6,300 lb O_2/d
	AOR at 68 °F and 14.7 psia:	244.5 lb O_2/hr	5,868 lb O_2/d
	SOTR	621.47 lb O_2/hr	14,915 lb O_2/d
results:			
	resulting number of diffusers	180 MAGNUM 2000 fine	
	resulting standard air flow rate (ASCE):	2,062 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	2,097 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	1.75 SCFM/ft	5.34 SCFM/m
	membrane specific air flow rate	3.3 SCFM/ft^2	
	volume specific aeration rate	0.045 SCFM/ft^3 of water	
	volumetric aeration rate	45.6 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.76 SCFM/ft^2 basin surface	
	mixing energy	31.44 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	8.14 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.76 psi	new diffuser!
	total nominal diffuser length	1,181.2 ft	
	total nominal membrane area	620.0 ft^2	
	diffuser density	22.9 %	
	number of laterals	12	
	diffusers per header	15	
	distance between diffuser axis	20.69 in	
	diffuser grid area	2,148 ft^2	
	Grid Density	79 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	169.0 °F at blower discharge	
	standard oxygen transfer capacity	13.5 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	5.7 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	107.0 with 65% blower efficiency	
	DAILY OPERATING COST @ $0.1/kWh $	191.56	
Projected values:			
	SOTE***	28.80 %	1.8 %/ft
	AOTE	15.8 %	1.0 %/ft
	SSOTE***	17.4 g $O_2/m_N^3/m_{id}$	
	AOTE	9.5 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

OTT GROUP

design criteria: *Future Maximum AOR. Zone 4*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:	α factor:	.55	
	β-factor:	0.95	
	DO:	1 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	68.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 20°C and 14.7 psia:	131.2 lb O_2/hr	3,150 lb O_2/d
	AOR at 68 °F and 14.7 psia:	131.2 lb O_2/hr	3,150 lb O_2/d
	SOTR	278.44 lb O_2/hr	6,683 lb O_2/d
results:	resulting number of diffusers	96 MAGNUM 2000 fine	
	resulting standard air flow rate (ASCE):	971 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	988 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	1.54 SCFM/ft	4.71 SCFM/m
	membrane specific air flow rate	2.9 SCFM/ft^2	
	volume specific aeration rate	0.021 SCFM/ft^3 of water	
	volumetric aeration rate	21.5 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.36 SCFM/ft^2 basin surface	
	mixing energy	14.80 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	8.10 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.71 psi	new diffuser!
	total nominal diffuser length	630.0 ft	
	total nominal membrane area	330.7 ft^2	
	diffuser density	12.2 %	
	number of laterals	8	
	diffusers per header	12	
	distance between diffuser axis	26.34 in	
	diffuser grid area	1,432 ft^2	
	Grid Density	53 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	168.4 °F at blower discharge	
	standard oxygen transfer capacity	6.1 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	2.9 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	50.2 with 65% blower efficiency	
	DAILY OPERATING COST @ $0.1/kWh $	89.83	
Projected values:	SOTE***	27.41 %	1.7 %/ft
	AOTE	15.1 %	0.9 %/ft
	SSOTE***	16.5 g $O_2/m_N^3/m_{id}$	
	AOTE	9.1 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project:	TAMPA DAR
date:	1/21/2013
membrane type:	FLEXSIL
perforation:	fine
diffuser type:	MAGNUM 2000

design criteria: *Future Maximum AOR. Zone 5*

applied to: *ONE ZONE OF FOUR*

basin data:	**basin length**	**52.0 ft**	
	basin width	**52.0 ft**	
	water volume	**46,000 ft^3**	
	water surface	**2,704 ft^2**	
	basin area	**2,704 ft^2**	
	side water depth	**17.0 ft**	
	submergence of diffuser @ centerline	**16.3 ft**	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:	**α factor:**	**.55**	
	β-factor:	0.95	
	DO:	1 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	68.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 20°C and 14.7 psia:	**78.7 lb O_2/hr**	**1,890 lb O_2/d**
	AOR at 68 °F and 14.7 psia:	**78.7 lb O_2/hr**	**1,890 lb O_2/d**
	SOTR	**167.08 lb O_2/hr**	**4,010 lb O_2/d**
results:	**resulting number of diffusers**	**64 MAGNUM 2000**	**fine**
	resulting standard air flow rate (ASCE):	**608 SCFM (@ 68°F, 14.7 psia)**	
	air required under actual conditions:	**619 ACFM (Pamb = 14.7 psia, Tair = 77 °F)**	
	diffuser thoughput rate	**1.45 SCFM/ft**	**4.43 SCFM/m**
	membrane specific air flow rate	**2.8 SCFM/ft^2**	
	volume specific aeration rate	**0.013 SCFM/ft^3 of water**	
	volumetric aeration rate	**13.5 SCFM/1,000 ft^3 of water**	
	mixing aeration rate	**0.22 SCFM/ft^2 basin surface**	
	mixing energy	**9.28 W/m^3**	**4 min**
	min. required system pressure * Includes membrane and grid pressure losses	**8.07 psig**	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	**0.69 psi**	**new diffuser!**
	total nominal diffuser length	**420.0 ft**	
	total nominal membrane area	**220.5 ft^2**	
	diffuser density	**8.2 %**	
	number of laterals	**8**	
	diffusers per header	**8**	
	distance between diffuser axis	**41.39 in**	
	diffuser grid area	**1,432 ft^2**	
	Grid Density	**53 %**	
	theor. temperature of air @ 68°F influx, 14.7 psia	**168.1 °F at blower discharge**	
	standard oxygen transfer capacity	**3.6 lbs/hr/1000 ft^3 water**	
	oxygen transfer capacity in wastewater	**1.7 lbs/hr/1000 ft^3 water**	
	ESTIMATED BHP	**31.4 with 65%**	**blower efficiency**
	DAILY OPERATING COST @ $0.1/kWh $	**56.13**	
Projected values:	**SOTE*** **	**26.25 %**	**1.6 %/ft**
	AOTE	**14.4 %**	**0.9 %/ft**
	SSOTE* **	**15.8 g $O_2/m_N^3/m_{id}$**	
	AOTE	**8.7 g $O_2/m_N^3/m_{id}$**	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

layout results for OTT membrane tubular diffusers

project: TAMPA DAR
date: 1/21/2013
membrane type: FLEXSIL
perforation: fine
diffuser type: MAGNUM 2000

design criteria: *Future Maximum AOR. Zone 6*

applied to: *ONE ZONE OF FOUR*

basin data:	basin length	52.0 ft	
	basin width	52.0 ft	
	water volume	46,000 ft^3	
	water surface	2,704 ft^2	
	basin area	2,704 ft^2	
	side water depth	17.0 ft	
	submergence of diffuser @ centerline	16.3 ft	
state of air: standard conditions in accordance with ASCE standards:			
	density of air @ 68°F, 14.7 psia	75.18 lb/ 1,000 ft^3	
	oxygen mass%	23.2 %	
	mass of O_2 in 1000 cu ft of air @ 68°F, 14.7 psia	17.44 lb/ 1,000 ft^3	
process data:			
	α factor:	.55	
	β-factor:	0.95	
	DO:	1 mg/l	
	TSS:	3500 mg/l	
	$T_{wastewater}$:	68.0 °F	
	T_{air}:	77 °F	
	ambient pressure:	14.7 psia	
	actual oxygen transfer rate at 20°C and 14.7 psia:	52.5 lb O_2/hr	1,260 lb O_2/d
	AOR at 68 °F and 14.7 psia:	52.5 lb O_2/hr	1,260 lb O_2/d
	SOTR	111.37 lb O_2/hr	2,673 lb O_2/d
results:			
	resulting number of diffusers	48 MAGNUM 2000 fine	
	resulting standard air flow rate (ASCE):	442 SCFM (@ 68°F, 14.7 psia)	
	air required under actual conditions:	449 ACFM (Pamb = 14.7 psia, Tair = 77 °F)	
	diffuser thoughput rate	1.40 SCFM/ft	4.29 SCFM/m
	membrane specific air flow rate	2.7 SCFM/ft^2	
	volume specific aeration rate	0.010 SCFM/ft^3 of water	
	volumetric aeration rate	9.8 SCFM/1,000 ft^3 of water	
	mixing aeration rate	0.16 SCFM/ft^2 basin surface	
	mixing energy	6.73 W/m^3	4 min
	min. required system pressure * Includes membrane and grid pressure losses	8.05 psig	
	diffuser head loss * Include additional pressure capacity for cleaning flow rate!	0.67 psi	new diffuser!
	total nominal diffuser length	315.0 ft	
	total nominal membrane area	165.3 ft^2	
	diffuser density	6.1 %	
	number of laterals	8	
	diffusers per header	6	
	distance between diffuser axis	57.95 in	
	diffuser grid area	1,432 ft^2	
	Grid Density	53 %	
	theor. temperature of air @ 68°F influx, 14.7 psia	167.9 °F at blower discharge	
	standard oxygen transfer capacity	2.4 lbs/hr/1000 ft^3 water	
	oxygen transfer capacity in wastewater	1.1 lbs/hr/1000 ft^3 water	
	ESTIMATED BHP	22.7 with 65%	blower efficiency
	DAILY OPERATING COST @ $0.1/kWh $	40.69	
Projected values:			
	SOTE***	24.10 %	1.5 %/ft
	AOTE	13.3 %	0.8 %/ft
	SSOTE***	14.5 g $O_2/m_N^3/m_{id}$	
	AOTE	8.0 g $O_2/m_N^3/m_{id}$	

***:values guaranteed in accordance with EN 12255-15 and German Standards ATV 115, ATV M209, adsorption method, corrected to values projected using ASCE protocols.

OTT DIFFUSER EFFICIENCY
It's not just the installed membrane area or low flux rate

OTT has focused on providing high quality, energy efficient aeration systems since its inception in 1986. From the beginning, OTT has manufactured only tube diffusers. Only one major design change (the creation of the *Clip-In*™ Magnum™) and a few minor changes have been incorporated since the first diffuser was made. Continuous improvements in materials, quality control and production have yielded a product of unmatched performance.

OTT diffusers are more efficient, particularly at low flux rates, than other diffusers due to a number of synergistic factors.

1. **The patented air channel on the underside of the support tube**. This channel provides equal air distribution to all areas of the annulus between the support tube and the membrane throughout the operating range. All other tube diffusers use one or two holes in various places to introduce air. This contributes to unequal air distribution.
2. **The perforation method and pattern** OTT uses are trade secrets that no one else can duplicate. OTT perforation sizes are generally smaller than others which yields more perforations and bubble per unit surface area. They contribute to the efficiency.
3. **Non-perforated areas on the top and bottom.** These areas perform very specific functions. First the area on the bottom seals the air channel so that mixed liquor cannot flow back into the piping. The area on the top allows a perfect collapse of the membrane without folding on the top ridge. Together, air is forced out the sides. This is important at low flux rates. Competitive diffusers are perforated the entire surface. The result is that, at low flux rates, most of the surface below the centerline is not active and air preferentially will escape form the upper portions as the air flow is reduced.
4. **The membrane materials** have been developed with cooperation of a German government agency, universities, and private elastomer compounders to yield membrane materials that are unique to OTT. These materials have undergone continuous improvement over the years and are now considered to be the best membranes available.
5. **The optimized compounding** allows the perforations to close completely on shut off, even after years of use. Combined with the non-perforated area under the air channel, leak free performance is insured. Energy wasting check valves or other mechanisms are not required.
6. **The Quality Assurance and Quality Control** program OTT enforces on every membrane batch and diffuser are so tight that the variability in the performance from one membrane and diffuser to the next in flux rate, pressure loss and physical properties is unmatched. The extra attention during the production process to the consistency of the parameters impacting efficiency is a significant contributor to obtaining an optimum performance, even at very low flux rates.
7. **Testing**. Every diffuser is tested for pressure and flow prior to shipment. A very tight tolerance at a specific low flux rate means that every diffuser delivered will yield the same performance.

These features enable OTT to achieve SOTE values greater than the rest of the industry. In head to head oxygen transfer tests, OTT diffusers have consistently outperformed every other diffuser to which they have been compared.

Oxygen Transfer Technology

Efficiency By Design

OTT GROUP

MAGNUM®

Innovative design.

The OTT MAGNUM® membrane tube diffuser has been the leading diffuser of choice for use in the demanding aeration applications world-wide for more than 15 years.

The OTT **MAGNUM®** support tube was designed to combine the best of important ratios: highest strength to weight; the lowest installation time to active membrane surface; lowest piping length to diffuser length and lowest buoyancy to weight – an unrivaled combination. These factors yield an installed cost that is competitive with, if not lower than, any other system designed to efficient standards. Construction details such as the patented ***CLIP IN®*** connection and the patented membrane guide profile on the upper side of the support tube are a solid basis for operational reliability and durability. Every diffuser is air flow and pressure tested at the factory to ensure the highest degree of quality control and product uniformity. To the client, this guarantees an optimized, highly reliable and efficient aeration process for many years to come.

Stainless steel clamps
Membranes are retained on the diffuser body by stainless steel clamps which provide a uniform clamping pressure without wrinkling the membranes. Extra membrane material is provided to fold over the clamps for personnel and membrane protection.

Membranes
FLEXSIL® or FLEXNORM® membranes are optimally tailored to the type of wastewater and application. The highest quality standards and extensive QA/QC checks ensure continual high performance and reliability.

Lengths
The MAGNUM® is available in effective membrane lengths of 1,000, 1,500 and 2,000 mm. The overall diffuser length is 200 mm more in each case.

Perforation
The OTT perforation technique combined with 5 available perforation lengths yield an optimal bubble pattern for every application. This method is but one of many features that give OTT diffusers unrivalled efficiency. The efficiency of OTT diffusers has been proven by the results of numerous independent performance tests. The perforation of the membrane can be geared to plant –specific requirements – just talk to us.

Mounting socket
MAGNUM® membrane tube diffusers are available with connections to accommodate commonly available square and round pipe sizes.

The benefits at a glance.

+ effective lengths: 1000, 1500 und 2000 mm
+ high-quality membranes for any application
+ simple and fast installation: *CLIP IN®* allows simple and fast installation up to 250 units/hr
+ suitable for square and circular air headers
+ single-piece diffuser tube made from environmentally-friendly polypropylene
+ only one hole needed in the header-pipe

Technical data, installation video and installation instructions at

www.ott-group.com

CLIP IN®
The patented CLIP IN® locking bolt makes the MAGNUM® the easiest and quickest diffuser to install.

Single-piece construction
The MAGNUM® core is a single piece, injection molded membrane support tube made of virgin, recyclable polypropylene (PP). The structure and design make the MAGNUM® a unique product. Environmental sustainability of your plant is enhanced by using recyclable, environmentally inert materials. Quality is maintained by computer controlled production.

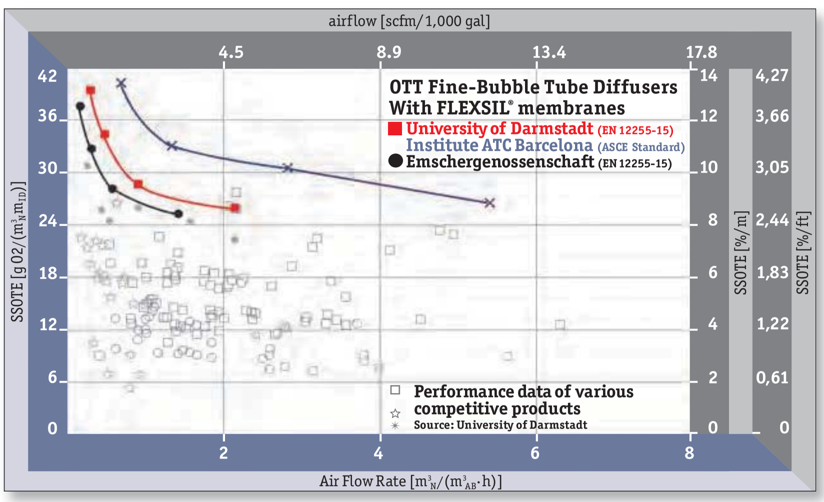
Air channel
Injection molding of the diffuser makes it possible to incorporate the air channel on the underside of the membrane support tube. The air channel evenly distributes air between the support tube and membrane.
This yields a consistent bubble pattern even at low air flux rates, giving a clear edge over any others with only holes for the air to enter.

Flooded tube
The MAGNUM® diffuser core is open at the ends and in the center. Thus, the diffuser's buoyancy is minimized and aerated fluid can freely circulate.

Fold-free membrane
The patented molded profile of the OTT MAGNUM® guarantees the membrane is fold-free whenever process air is switched off, especially in intermittent operations.
This detail is the basis for a high degree of mechanical integrity and durability of membranes.

OTT's MAGNUM®-membrane tube diffusers – simplicity, efficiency and quality yields lowest cost of ownership.

Installation with MAGNUM®2000FLEXSIL® membrane tube diffusers.



Oxygen transfer efficiency data from independent test institutes with full-floor coverage of basin. Complete test reports can be provided on request.

presented by

OTT North America LLC
1000 Peachtree Industrial Blvd,
Suite 6266
Suwanee, GA 30024

Phone: 001 770 476 1492
USsales@ott-group.com
www.ott-group.com

OTT GROUP

Nik Müller-Lenhartz · Berlin | Tenerife · 09-2012

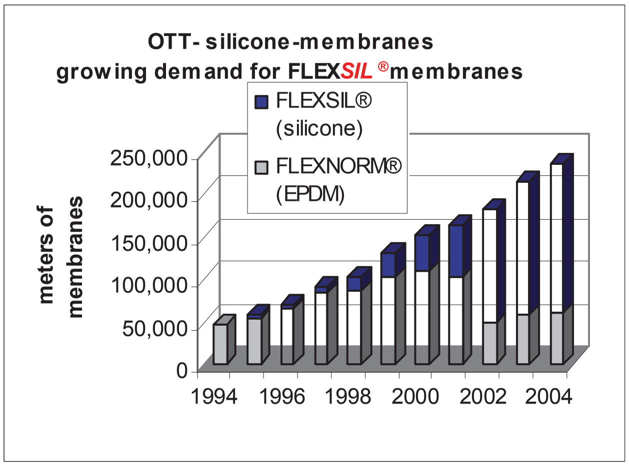
FLEXSIL® Silicone-Diffuser Membranes by OTT GROUP

OTT North America LLC

Most diffusers for wastewater aeration systems have been equipped with rubber membranes made from EPDM. The black EPDM membrane is standard for most tubes, plates and discs. Since 1998, OTT System GmbH, Langenhagan, Germany, has pioneered the use of a material that successfully sets higher standards for membrane lifetime and performance: **silicone**.

The great advantage of silicone membranes is that they will not age harden or shrink. Silicone does not contain softeners and the material will not age as does EPDM. **It has proven to be suitable for the high demands of modern wastewater. Silicone is resistant to UV radiation, oil, fat and organics, including aromatics, that severely attack EPDM.** These properties make silicone-membranes **the perfect choice for treatment plants of the food, pharmaceutical and chemical process industries.** Breweries, dairies and poultry plants have experienced marked improvement in their aeration process and lowered costs due to the longer membrane life.

The Teflon-like surface finish of a silicone membrane reduces the chance that chemicals and biota will adhere to the membrane. Silicone is widely used in applications with very high temperatures – up to 284 °F. Therefore these membranes can be installed in deep tanks with hot blower air and in industrial plants with a high water temperatures.



The chart on the left illustrates the growth of FLEXSIL® membranes. Since 2001, OTT has sold more tube-diffusers with silicone membranes than with EPDM-membranes. FLEXSIL™ membranes represent an increasing percentage of their production.

OTT FLEXSIL® membranes are the right choice for very high demands of today's wastewater. FLEXSIL® membranes are a cost effective investment in reliability and performance of modern wastewater-aeration systems. OTT has the longest experience with silicone membranes and sells more silicone membranes than any other manufacturer. The oldest known North American installation of FLEXSIL® was installed in 2002. This plant changed from the EPDM membrane originally installed after a dairy moved to town. This plant reports no loss of performance since start up.

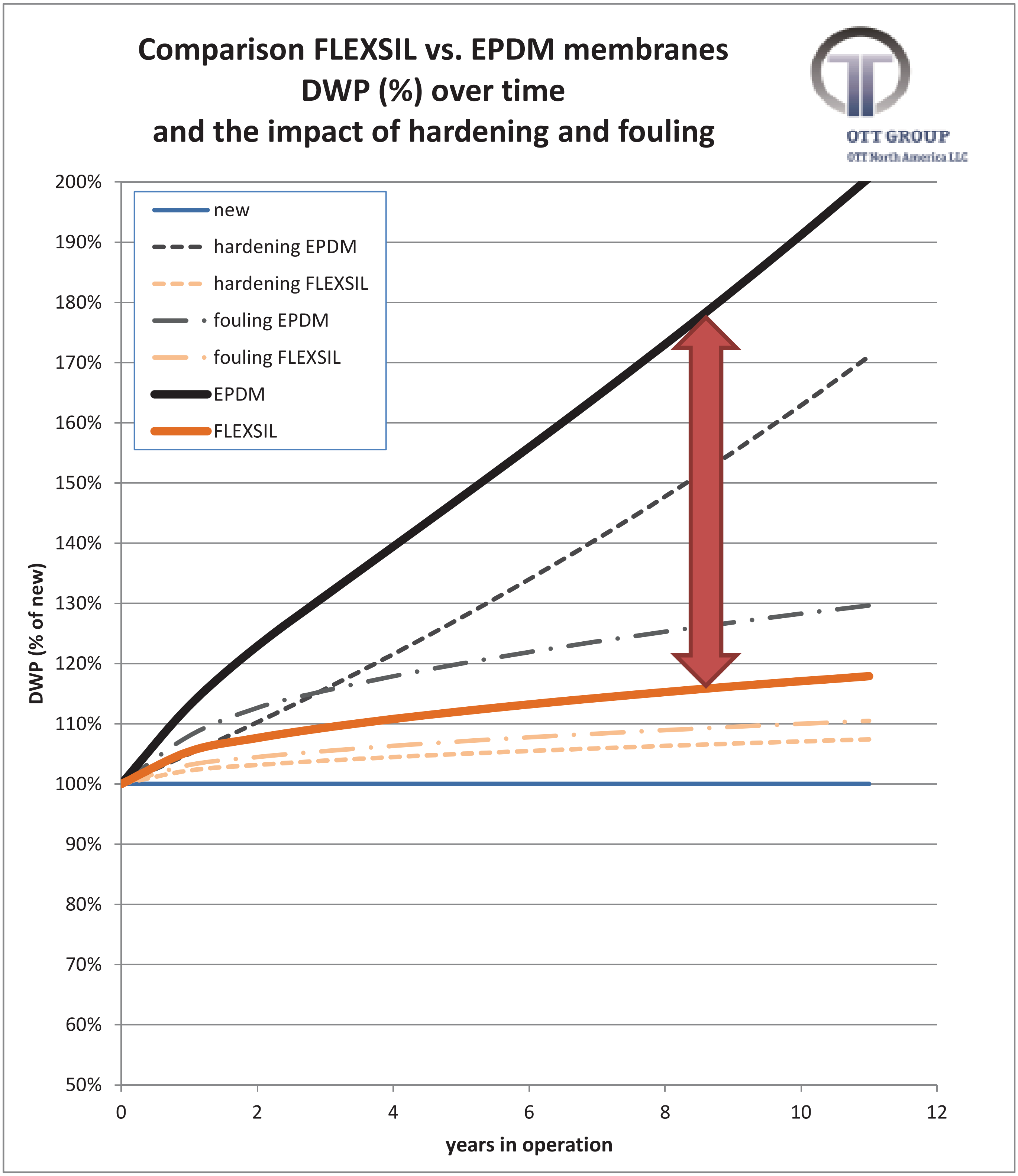
A few of the Benefits of OTT FLEXSIL® membranes:

- excellent performance
- extended life without loss of performance
- resistant against organics, oil, fat and grease
- free from softeners or plasticizers
- smooth surface – requires cleaning less often
- temperature resistant to 140° C
- suitable for intermittent and continuous aeration
- installed in all types of WWTPs – over 1000 worldwide

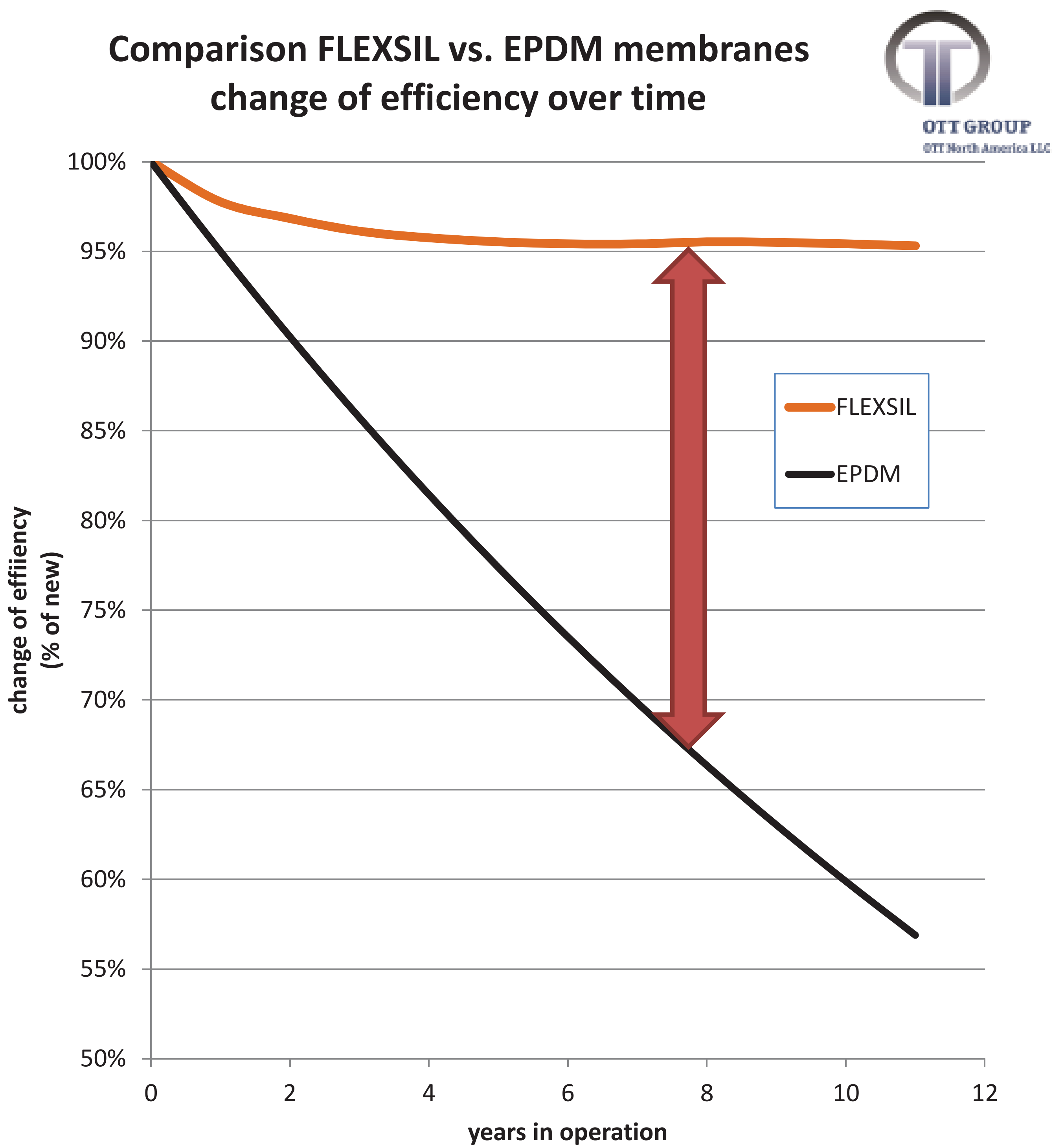
OTT has also adaptors in stock which allow installation of complete OTT diffusers with FLEXSIL™ membranes on existing aeration systems using other diffusers brands attached with ¾" connections.
For more information on FLEXSIL™ membranes, contact our North American distributor.

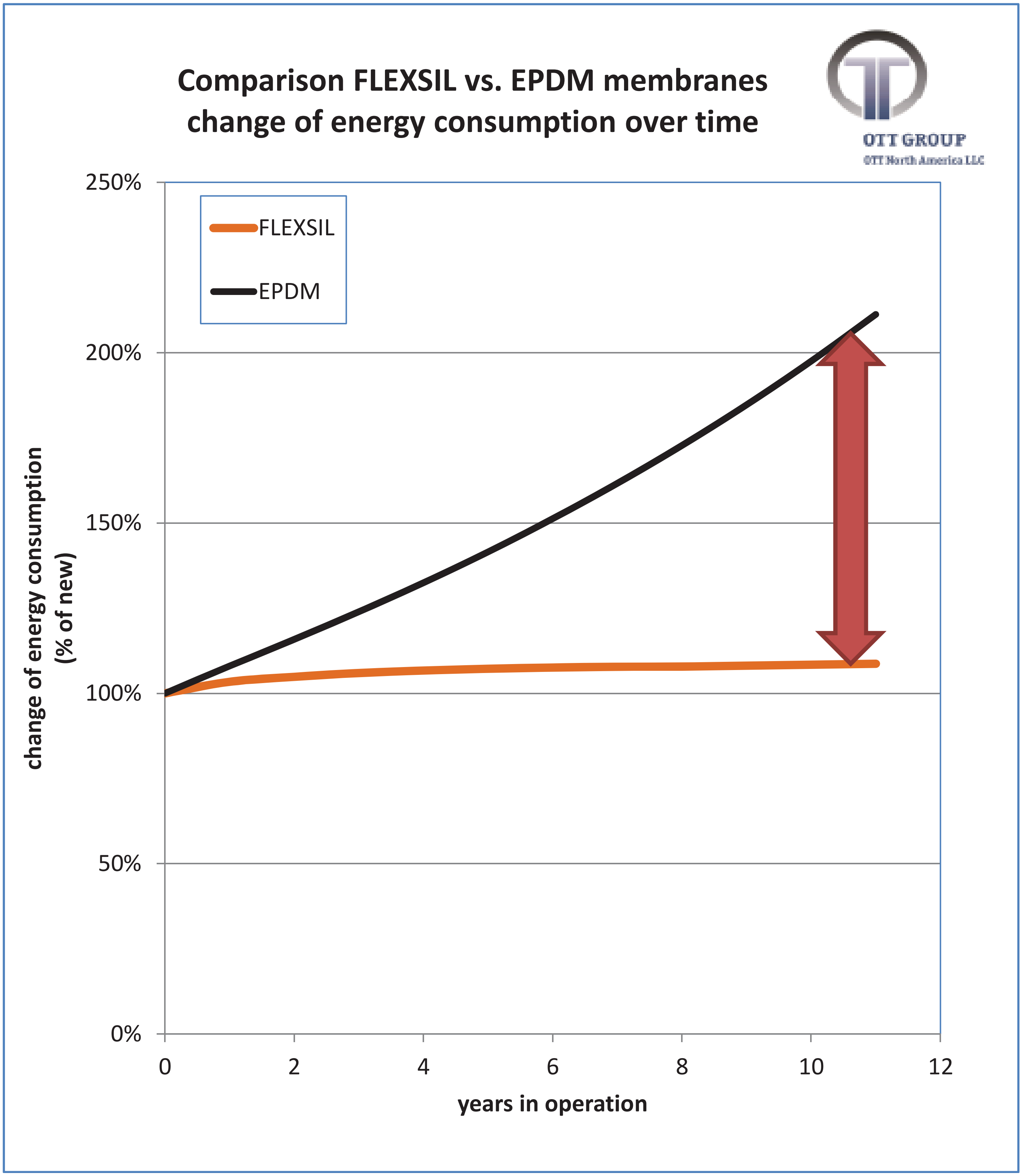
OTT North America, LLC
1000 Peachtree Industrial Blvd.
Suite 6266
Suwanee, GA 30024
Tel: 770-476-1492
Fax: 678-302-9962

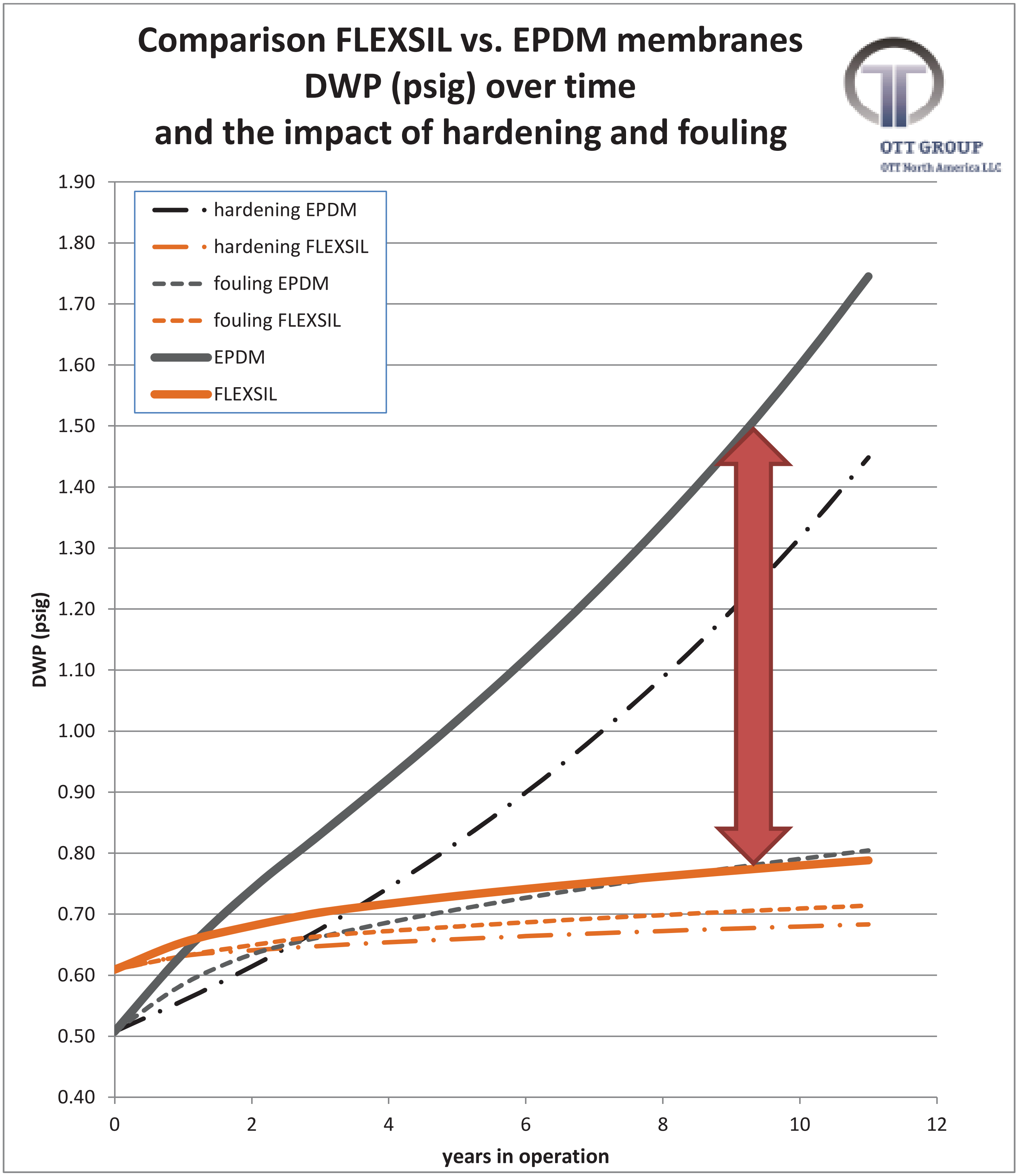
info@ott-group.com
www.ott-group.com


Comparison FLEXSIL vs. EPDM membranes
DWP (%) over time
and the impact of hardening and fouling
OTT GROUP
OTT North America LLC
new
hardening EPDM
hardening FLEXSIL
fouling EPDM
fouling FLEXSIL
EPDM
FLEXSIL
200%
190%
180%
170%
160%
150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%
DWP (% of new)
0
2
4
6
8
10
12
years in operation

Comparison FLEXSIL vs. EPDM membranes change of efficiency over time




Comparison FLEXSIL vs. EPDM membranes
change of energy consumption over time
OTT GROUP
OTT North America LLC
FLEXSIL
EPDM
250%
200%
150%
100%
50%
0%
change of energy consumption
(% of new)
0
2
4
6
8
10
12
years in operation


Comparison FLEXSIL vs. EPDM membranes
DWP (psig) over time
and the impact of hardening and fouling
OTT GROUP
OTT North America LLC
hardening EPDM
hardening FLEXSIL
fouling EPDM
fouling FLEXSIL
EPDM
FLEXSIL
DWP (psig)
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0
2
4
6
8
10
12
years in operation

Oxygen Transfer Technology

Efficiency by Design

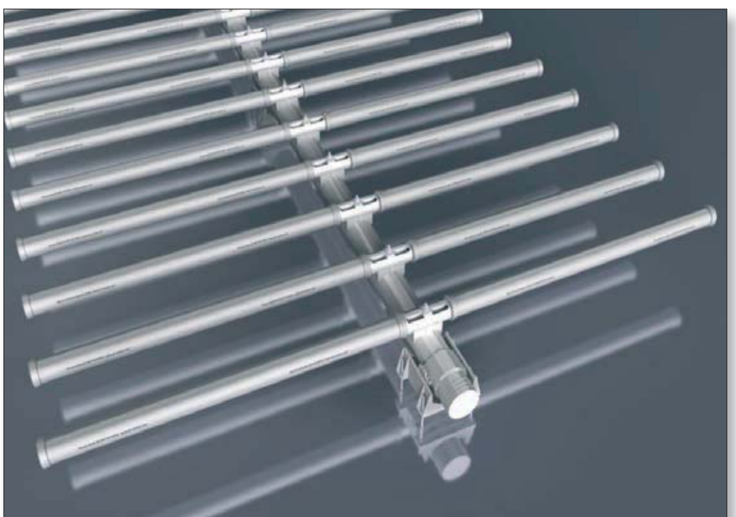
OTT GROUP

AirRex piping system

AirRex – functionality, durability, cost effectiveness.

AirRex is the first plastic piping assembly designed expressly for aeration service. It is available as a kit. The modular concept in combination with the revolutionary connection and the specially designed supports allow fast installations at low costs.

AirRex can be retrofitted into basins equipped with fine bubble aeration to increase efficiency and yield a reasonable payback as well as older, coarse bubble installations. New installations will be the lowest cost high efficiency diffuser system available.



The combination of low cost reinforced polypropylene piping, fast installation and our high efficiency **MAGNUM®** diffusers make the **AirRex** system superior to any other plastic or PVC piping systems.

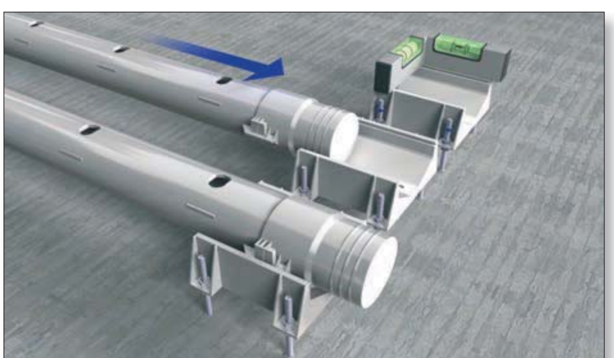
Operators, engineers and the public authorities do benefit from this system through:

- **reduced design costs through standardized modules with standardized efficiencies**
- **fastest installation times because of the revolutionary connection concept**
- **guaranteed operational safety as a result of experience and engineering**
- **highest efficiency per installed unit length of diffuser because of the use of the MAGNUM® diffuser**

AirRex – easiest to design and to install aeration systems.

With only 3 different elements **AirRex** can be combined in lenghts of about 2 meter (6.6 ft) for any basin configuration.

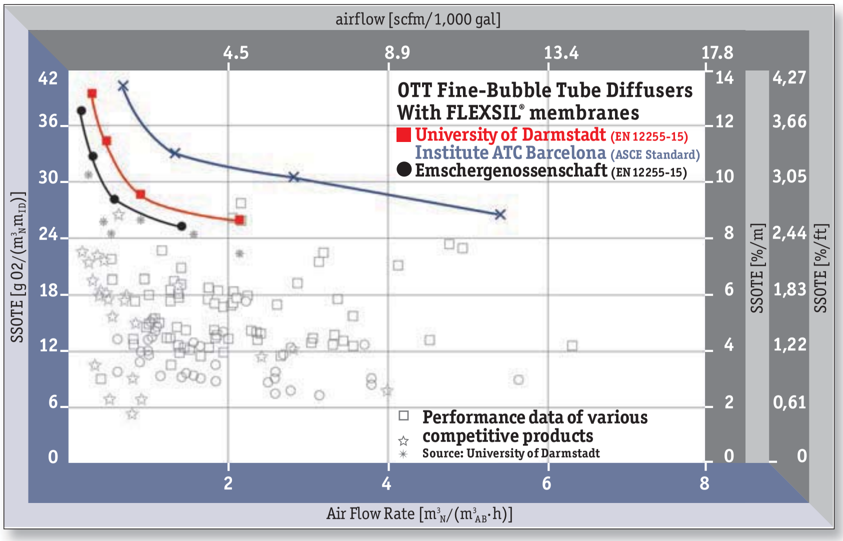
The **AirRex** piping system is the first choice for operators, OEMs and engineers that demand high efficiency and quality at a lower cost than stainless steel piping.



AirRex has a maximum working temperature of 110 C, far exceeding that of other plastics.
The design of the supports with the integrated slide rails allow for expansion and contraction while maintaining structural integrity.

- **no pipe welding, coupling or adhesives required during installation**
- **designed to withstand thermal expansion**
- **can be connected to any existing piping system**
- **all components are free of PVC and recyclable**

OTT's AirRex piping system and MAGNUM® tube diffusers – The next level aeration technology.



Oxygen transfer efficiency data from independent test institutes with full-floor coverage of basin. Complete test reports can be provided on request.

presented by

OTT North America LLC
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Suwanee, GA 30024

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OTT GROUP

Nik Müller-Lenhartz · Berlin | Tenerife · 09-2012

OTT FLEX*SIL*® MEMBRANE SPECIFICATION

OTT GROUP

1. Product

Flex*Sil* is a poly-organo siloxane based elastomer with an anti-adhesive surface. The word *siloxane* is derived from the words **sil**icon, **ox**ygen, and **a**lkane**.** Polymerized siloxanes with organic side chains are commonly known as silicones or as *polysiloxanes*. Since it contains no softeners or nitrogen compounds, **Flex*Sil*** will not leach NDMA or precursors.

Deposition of precipitating chemicals, salts, and biological slimes is five to ten times lower than that of typical EPDM elastomer based membranes. **Flex*Sil*** is resistant to chemical attack by grease, oil, and hydrocarbons, particularly aromatics. **Flex*Sil*** also exhibits higher heat resistance and tensile strength than the normal EPDM membrane. **Flex*Sil*** is impervious to UV damage. **Flex*Sil*** does not age harden and maintains the same energy consumption over the life of the membrane.

2. Product Characteristics

Color:	Gray
Specific Weight:	1.18 $g/cm^3 \pm 0.03$
Shore Grade Hardness	A 53 ± 5
Maximum Continuous Operating Temp.	140° C (285° F)

3. Mechanical Values

Unperforated Tensile Strength	> 11 N/mm^2
Tensile Dilation	> 630%
Elasticity	> 40%
Residual Tensile Strength	> 35 N/mm

4. Main Dimensions

Inside Diameter	63.5 mm, +0.03, -0.07
Perforated Length	500 mm, 750 mm, 1000 mm
Overall Length	560 mm, 810 mm, 1060 mm
Wall Thickness	1.45 +.15/-.10 mm

5. Performance Data

Perforation Length	0.6 mm	1.2 mm	2 mm
Maximum Airflow per meter, SCFM	3.5	9.4	14.0
Minimum Airflow per meter, SCFM	0.3	0.6	1.2
Air Flux Rate, $SCFM/ft^2_{\text{active surface}}$	0.17 – 2.03	0.38 - 5.55	0.74 - 8.13
Pressure Drop, psi	0.75 – 1.01	0.44 – 1.01	0.26 – 1.01

6. Application

The **Flex*Sil*** membrane is recommended for use in industrial plants with high concentrations of fats, oils, greases and organic compounds and in municipal plants where precipitating chemicals, such as Ferric Chloride, are in use. Please consult the factory for resistance to specific chemicals.

7. Service Life and Maintenance

The **Flex*Sil*** membrane requires very little maintenance. Periodic (30 min/wk or 5 min/day) over inflation to 1.5 to 2 times the maximum flux rate is recommended. The material has been in service in Europe since 1996 and in North America since 1999. The oldest known installation in the US was changed from **Flex*Norm*** in 2002 due to deterioration caused by FOG from a dairy that began discharging in 2002. To date, no **Flex*Sil*** installation has required membrane replacement as a result of chemical attack or biological breakdown. The anticipated life is 8 to 10 years.

revised October 23, 2012

Warranty Conditions for OTT GmbH Membrane Tube Diffusers and Membranes for [redacted]

1. Object of delivery

1.1. Item description

- MAGNUM® membrane tube diffuser
- FLEX*SIL*® membranes (silicone)
- OTT supplied aeration components

1.2. Technical data

Dimensions and specifications of the diffusers are shown in the drawings. Expected system performance parameters are shown in the data sheets for the products concerned. The performance parameters quoted in such sheets are the result of, in part, factors and standards outside the supplier's realm of judgment and influence.

The pressure losses quoted refer to new diffusers that have been properly initialized (full aeration for twenty four hours) operating in clean water. OTT GmbH cautions that, particularly in the presence of high calcium, iron and other compounds, process-related deposits may occur which could lead to an increase of the pressure loss. When specifying blowers, sufficient pressure reserves have to be planned to take this phenomenon into account. In addition, arrangements to supply air to diffusers in excess of normal operating ranges for the purposes of in situ cleaning of the membranes should be provided. This may require even higher pressure, depending upon the piping arrangements.

2. Warranty case

FLEX*SIL*®- membranes are warranted against defects in material and workmanship. In order to validate claims of warranty, failed membranes must be returned to the factory in the removed condition and sealed to maintain the integrity of the condition for forensic examination. A written evaluation of the results will be provided, should it be determined that failure was due to other causes such as mechanical stress or chemical attack by constituents in the wastewater.

In addition, FLEX*SIL*®- membranes are warranted against an increase in the Shore-A hardness of the membrane above 75 during the warranty period. The original hardness of a FLEX*SIL*® membrane is 60 ± 5 Shore A.

Steel components supplied by OTT GmbH are similarly warranted against defects in materials and workmanship.

3. Warranty period

The warranty period for tube diffusers supplied by OTT GmbH shall amount t[redacted]months from commissioning, but not more than a maximum o[redacted]months from the date of delivery.

The warranty period for steel components supplied by OTT GmbH shall amount to 24 months from commissioning, but not more than a maximum of 30 months from the date of delivery.

4. Scope of warranty

Warranty shall be limited to the delivery of free replacements for justifiably rejected parts. Such free supply of replacement parts does not prolong the warranty period indicated under Item 3, not even with respect to the replacements supplied.

In the event that membranes, clamps, gaskets or connectors, other than original OTT GmbH parts were used, or installation, operating and maintenance instructions neglected, any and all warranty entitlements shall be void.

OTT GmbH grants an unlimited warranty for the products sold by them. However, this product responsibility has to be limited to circumstances which can be influenced by the grantor of the warranty.

Failures due to the following causes are specifically excluded:

- deposits on or underneath the membranes, which are due to the process
- deposits underneath the membranes, which are due to improper cleaning of air supply pipes prior to diffuser installation
- deposits underneath the membranes, which are due to improper cleaning of air supply pipes prior to improper blower air filters
- deposits caused by insufficient maintenance of the diffusers
- damages caused by flow conditions exceeding normal values, particularly those imposed by submerged mixers
- damages resulting from the specific composition of the sewage water
- damages resulting from improper installation or mechanical forces

Membrane tube diffusers and membranes by OTT GmbH have been working reliably and without any problems for years in wastewater treatment plants with domestic waste water. In case of sewage waters containing a share of industrial sewage, one has to ensure that the sewage does not contain any substances damaging EPDM or silicone. In addition to that, suitability of the membranes should be examined on the basis of the actual composition of the sewage, prior to using the diffusers.

Once technical details have been clarified, above limitation of the promise of warranty may be revoked. Individual terms of guarantee (e.g. in combination with tender requirements) can be agreed upon in written form.

5. Notice of defect

Any defects have to be notified to manufacturer immediately, within two working days after they became known. Manufacturer reserves the right to inspect the damage himself or have it inspected by a person appointed by him. If, for compelling reasons, a replacement has to be supplied prior to inspection or acknowledgement of the warranty case, such replacement shall be invoiced on a preliminary basis until clarification of liability.

6. Other contract terms

In addition to these warranty conditions, the general contract terms for the performance of services (German VOL/B), last amended in 2003, shall apply. The full text of the German VOL/B is available from OTT GmbH or may be retrieved from the internet at www.ott-system.com.

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Suwanee, GA 30024
Office: 770-476-1492 or Cell: 770-377-0300
Fax: 678-302-9962
info@ott-group.com www.ott-group.com

North American Sales Partner
HYDRO-LOGIC ENVIRONMENTAL INC.
762 Upper James St., Suite 250
Hamilton, Ontario
CANADA L9C 3A2
Fax: 905-777-8678 Phone: 905-777-9494
info@hydrologic.ca www.hydrologic.ca

OTT Diffuser References in North America

(Partial Listing)

Gary Hickman – Manager WWTP Jackson Pike - City of Columbus Columbus, Ohio Phone: 614-645-3138 Extension: 1201	150 MGD
Joe Baxter - Operations Supervisor Dry Creek - Sanitation District No. 1 Villa Hills, Kentucky Phone: 859-331-6674 Extension: 3106	50 MGD
Tim Snider City of Troy Troy, Ohio Phone: 937-339-1410	6 MGD
Bob Hornic City of Van Wert Van Wert, Ohio Phone: 419-238-9666	2.5 MGD
Shannon Grant, Troy Dorcas, Peter McCarthy, Mike McDermaid ADI Systems Fredericton, New Brunswick Phone: 506-452-9000	6 Projects in Canada and US
Joe Hanks Dale Services Corporation Dale City, Virginia Phone: 703-670-5131	8 MGD
Kevin Ross BioKyowa, Inc. Cape Girardeau, Missouri Phone: 573-335-4849	0.6 MGD

TETRA TECH, INC.

ATTACHMENT F
OVIVO MEMBRANE PANEL PROPOSAL
(OPTION 7)

AEROSTRIP® Fine Bubble Diffusers Proposal

For

CITY OF TAMPA FL

Provided on **January 18, 2013**

By
Ovivo USA, LLC
4255 Lake Park Blvd., Suite 100
Salt Lake City, Utah
84120-8201
USA
www.ovivowater.com

Ovivo USA, LLC
4255 Lake Park Blvd., Suite 100
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USA

Telephone: 801.931.3000
Facsimile: 801.931.3080

www.ovivowater.com

OVIVO
Bringing water to life

January 18, 2013

To: John Verscharen
TSC-Jacobs North Florida
24156 SR 54
Suite 3
Lutz, FL 33549

Subject : Preliminary Design
Tampa WWTP,FL
AEROSTRIP® System

John,

Please find the design for the finest aeration system available today—**an Ovivo AEROSTRIP® System**. AEROSTRIP systems have been around since 1996 (since 2001 in the United States) with approximately 1,000 installations. AEROSTRIP systems are the ***proven*** longest lasting (16 years and counting), ***proven*** lowest maintenance (minimal tank draining), and ***proven*** lowest energy (10-50% less) fine pore diffusion system on the market.

For Tampa WWTP, we recommend a total of 1,600 Aerostrip (800 each Q3-18 and 800 each Q 3.5-18) diffusers. We have based our design on the information provided to us by your office.

The following is a summary of the operating conditions.

	CURRENT AVG	CURRENT MAX	FUTURE AVG	FUTURE MAX
Design SOR(lb/hr)	4926.7	7709.7	6897.4	10793.6
Design Airflow(scfm)	13,324	21,625	19,119	31,529
∆P @ at Top of Drop(psig)	8.49	8.61	8.57	8.76

Note: Pressures above consider 0.5 psi fouling allowance above normal pipe loss, trans-membrane pressure, and static head.

A full summary of the design conditions is included in Attachment B.

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84120-8201
USA

Telephone: 801.931.3000
Facsimile: 801.931.3080

www.ovivowater.com

The initial investment in AEROSTRIP will pay dividends for the plant over the long term (Figure 1). AEROSTRIP systems use substantially less air and have significantly lower maintenance requirements than standard EPDM-based systems. Ovivo can provide third-party full-scale documentation of AEROSTRIP oxygen transfer performance after 11 years of continuous operation. Numerous third party clean water oxygen transfer tests are also available.

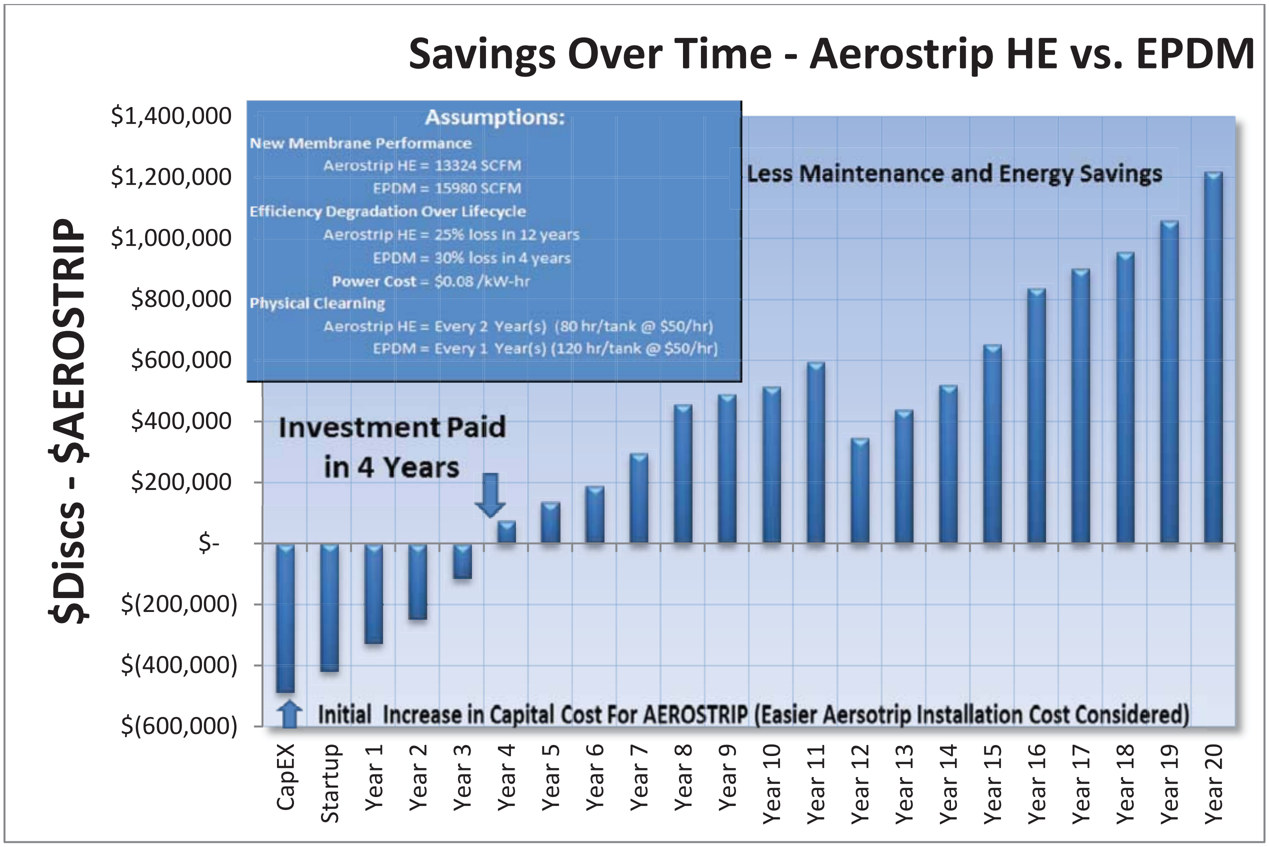

Figure 1. Comparison of ownership costs of AEROSTRIP vs EPDM System. Initial investment in AEROSTRIP will pay for itself in 4 years in reduced energy and maintenance. Interest rate not considered, but no escalation in energy or maintenance costs are considered either.

We have assumed the AEROSTRIP® membranes will be replaced after 12 years at a cost of $300,000.

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Ovivo's scope of supply includes all diffusers, in basin-piping from the bottom of the drop, diffuser and piping mounting hardware, and 2% complete diffuser shelf spares.

AEROSTRIP systems may be installed in a conventional manner with SS drop pipes and PVC laterals. AEROSTRIP diffusers are connected to the PVC laterals with threaded nipples, compression fittings and short lengths of durable and flexible HDPE or reinforced PVC 1-inch tubing. All PVC is minimum Schedule 40. Other manufacturers use thin-walled products. We do not. These thin-walled products may have adequate pressure ratings on paper, but they do not hold up well over time.

AEROSTRIP Systems may also be installed with 2-inch HDPE drop pipes which connect the diffusers directly to the air header at the top of the tank. This system connects 2-6 diffusers per drop, allowing excellent isolation potential for operations. We have depicted the system using PVC laterals for Tampa, but either system may be used. In both cases, Ovivo manufactures and supplies all in-basin piping specifically for each project. Figure 2 depicts the two systems.

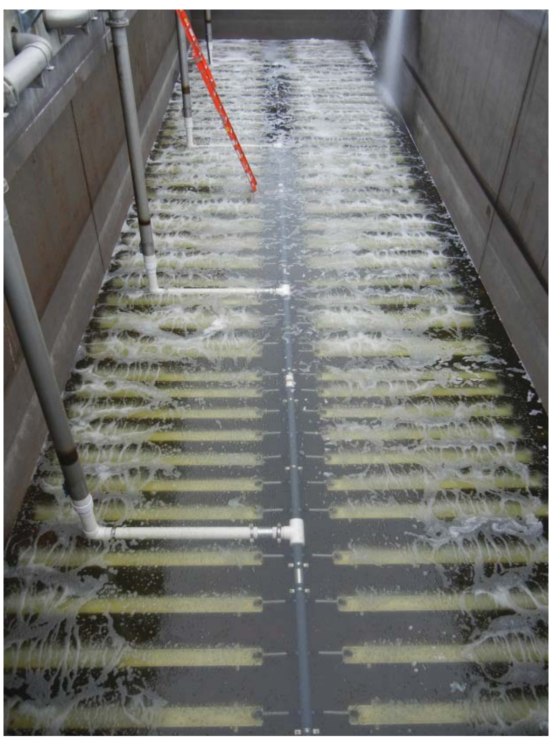

Figure 2. Two basic methods of in-basin piping. Left picture is conventional SS drop to PVC laterals (laterals may also be SS). Right picture is 2-inch HDPE drops connected to two to six individual diffusers. HDPE or flexible PVC 1-in tubing with compression fittings connects individual diffusers in both cases. More installation pictures are included in Attachment C.

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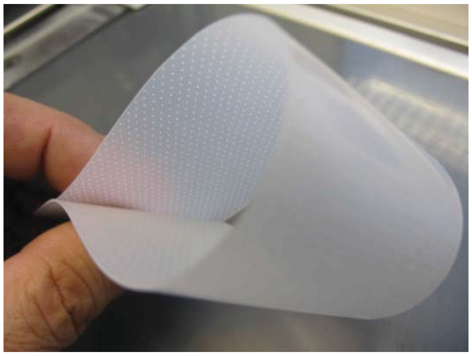

Figure 3. AEROSTRIP perforation technology

Using polyurethane membranes is not enough—polyurethane just provides a suitably strong material with which to work. The advanced perforation technology of AEROSTRIP ensures ***each perforation is a check valve*** when the air is shut off. Approximately 0.4-0.6 psig (11-16 in H_2O) is required to open up pores to allow air to pass. Typical operating trans-membrane pressure is 0.7-0.9 psi (19-25 in H_2O). Our perforation technology has advanced in recent years compared to other polyurethane manufacturers whose membranes still operate at substantially higher trans-membrane pressures.

Each individual diffuser (yes, every one) is factory-tested at two different air fluxes and is tested in a submerged condition prior to shipment to the site. This level of quality control ensures that pores ***will indeed close when the air is shut off*** without backflow of mixed liquor. The factory testing also ensures that even pattern distribution will occur ***even at low air flow rates*** along the length of the diffuser and among all diffusers in the tank. ***An even distribution pattern is essential to delivering high efficiency***.

Figure 4. Each <u>individual</u> AEROSTRIP diffuser is factory-tested

Due to the advanced perforation technology, AEROSTRIP diffusers can be ***fully flexed*** (air evacuated condition to a higher flux condition) without fouling. The flex cycle is programmed to occur daily for a few minutes and is the key to our longevity and lack of significant efficiency degradation. Repeatedly flexing the membrane ***loosens and squeezes deposits before significant and permanent pore fouling occurs***. A simple bump used by other manufacturers is largely ineffective over the long-term.

Figure 5. AEROSTRIP Automated Relax/Flex Cycle

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Design life of AEROSTRIP® diffusers is 15 years without membrane replacement. Ovivo can provide a 10-year guarantee, based on our standard conditions.

Please feel to contact me at any time at (801) 931 3242.

Very truly yours,

Tom Leland, P.E.
Group Manager
Aeration Processes
AEROSTRIP®, Cleartec®, and Carrousel® Systems

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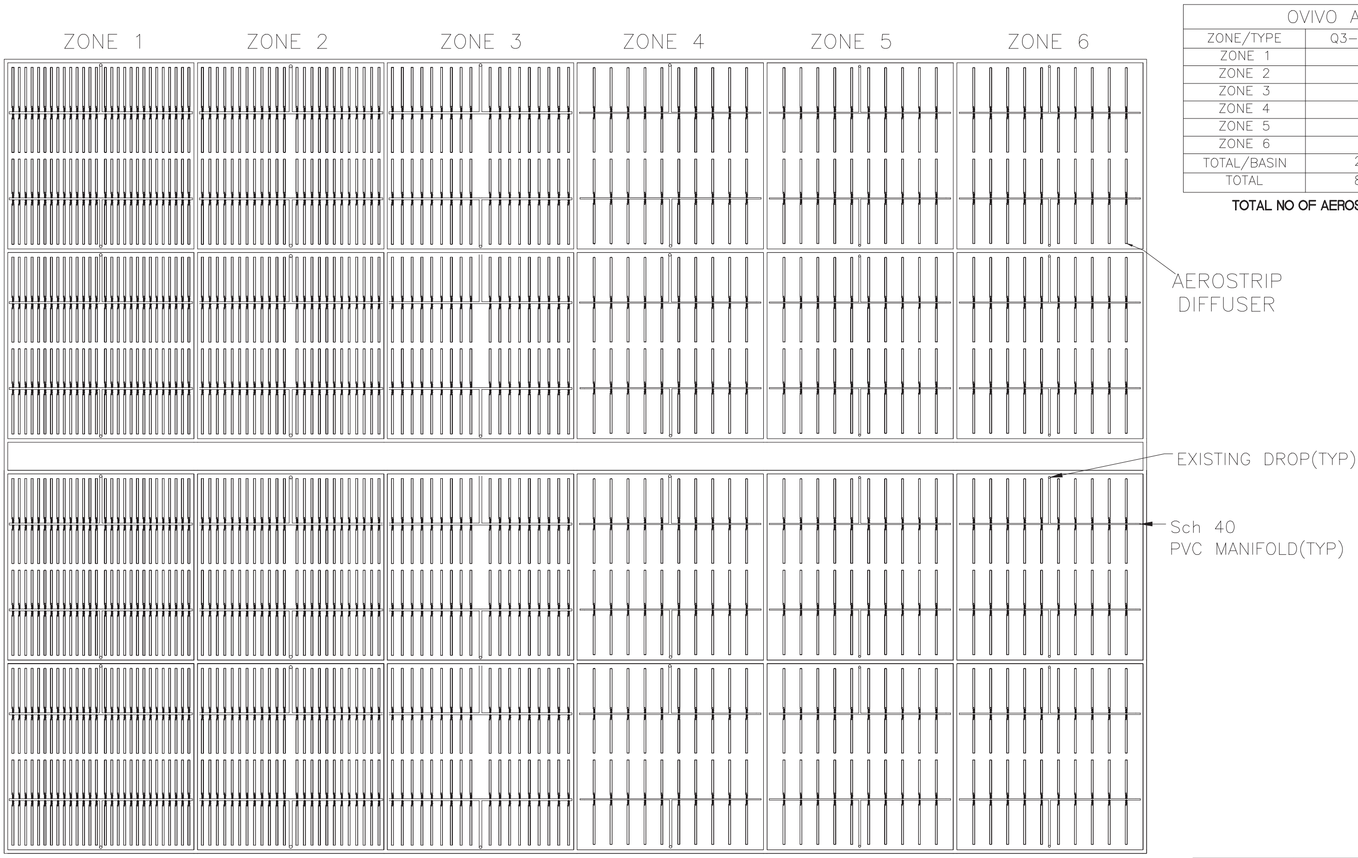
ATTACHMENT A
AEROSTRIP®
DRAWINGS



OVIVO AEROSTRIP		
ZONE/TYPE	Q3-EU-18	Q3.5-EU-18
ZONE 1	56	56
ZONE 2	48	48
ZONE 3	36	36
ZONE 4	20	20
ZONE 5	20	20
ZONE 6	20	20
TOTAL/BASIN	200	200
TOTAL	800	800

TOTAL NO OF AEROSTRIP = 1600

D

THIRD ANGLE PROJECTION

OVIVO
Bringing water to life

CITY OF TAMPA
FLORIDA
-

REF. FROM:	-	DO NOT SCALE PRINTS
DATE (mm/dd/yyyy)	01/18/13	WORKMANSHIP STANDARD ES0001 APPLIES
DRAWN	-	ORIGINAL S.O.
CHECK'D	KGM	-

REVISION	EN/ECO	BY	CHECK'D	DATE	
INITIAL RELEASE	-	-	-	--/--	A

DWG. NO. -

SHEET 1 OF 1

REV A

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ATTACHMENT B
AEROSTRIP®
CALCULATIONS

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OVIVO
Bringing water to life

CITY OF TAMPA, FL: AEROSTRIP @ CURRENT AVERAGE, CUREENT MAX, FUTURE AVERAGE AND FUTURE MAX.
18 JAN 2013

Operating Conditions	Units	CURRENT AVERAGE	Train design	Cell design 1	Cell design 2	Cell design 3	Cell design 4	Cell design 5	Cell design 6
AOR	lb/day	50,000	12,500	4,000	3,500	2,500	1,250	750	500
alpha	fraction	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
beta	fraction	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Temperature	C	30	30	30	30	30	30	30	30
DO Concentration	mg/L	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Elevation	ft	50	50	50	50	50	50	50	50
AOR/SOR	%	42.3%	42.3%	42.3%	42.3%	42.3%	42.3%	42.3%	42.3%
Design SOR	lb O_2/day	118,241	29,560	9,459	8,277	5,912	2,956	1,774	1,182
Hours per day aerating	hr	24	24	24	24	24	24	24	24
Design SOR	lb O_2/hr	4926.7	1231.7	394.1	344.9	246.3	123.2	73.9	49.3
Number of Trains/Cells		---	---	1	1	1	1	1	1
Length	ft	---	---	53.00	53.00	53.00	53.00	53.00	53.00
Width	ft	---	---	53.00	53.00	53.00	53.00	53.00	53.00
Side Water Depth	ft	---	---	17.00	17.00	17.00	17.00	17.00	17.00
Immersion Depth	ft	---	---	16.67	16.67	16.67	16.67	16.67	16.67
Volume	MG	8.573	2.143	0.357	0.357	0.357	0.357	0.357	0.357
Air Flow Required For Process	scfm	---	---	973	858	618	321	171	107
Tank Flux Required For Mixing	scfm/ft2	---	---	0.10	0.10	0.10	0.10	0.10	0.10
Air Flow Required For Mixing	scfm	---	---	281	281	281	281	281	281
Design Air Flow	**scfm**	13,324	3,331	973	858	618	321	281	281
Membrane Area	sq ft	---	---	682	585	438	244	244	244
Operating Membrane Flux (Membrane Area)	scfm/ft2	---	---	1.43	1.47	1.41	1.32	1.15	1.15
Operating Tank Flux (Floor Area)	scfm/ft2	---	---	0.35	0.31	0.22	0.11	0.10	0.10
Bottom Coverage	%	---	---	24.3%	20.8%	15.6%	8.7%	8.7%	8.7%
SOTE At Operating Flux	**%**	---	---	39.0%	38.7%	38.4%	37.0%	38.0%	38.0%
Immersion Depth	ft	---	---	16.67	16.67	16.67	16.67	16.67	16.67
SOTE/ft of immersion	**%/ft**	---	---	2.3%	2.3%	2.3%	2.2%	2.3%	2.3%
ΔP Static	psig	---	---	7.23	7.23	7.23	7.23	7.23	7.23
ΔP Membrane	psig	---	---	0.74	0.74	0.74	0.73	0.72	0.72
ΔP Lateral Piping	psig	---	---	0.02	0.01	0.01	0.01	0.01	0.01
ΔP @ Top of Drop	psig	---	---	7.99	7.99	7.98	7.97	7.96	7.96
ΔP Fouling Allowance (engineer determined)	psig	---	---	0.50	0.50	0.50	0.50	0.50	0.50
ΔP @ at Top of Drop For Design	**psig**	8.49	8.49	8.49	8.49	8.48	8.47	8.46	8.46

Operating Conditions	Units	CURRENT MAX	Train design	Cell design 1	Cell design 2	Cell design 3	Cell design 4	Cell design 5	Cell design 6
AOR	lb/day	90,000	22,500	7,200	6,300	4,500	2,250	1,350	900
alpha	fraction	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
beta	fraction	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Temperature	C	30	30	30	30	30	30	30	30
DO Concentration	mg/L	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Elevation	ft	50	50	50	50	50	50	50	50
AOR/SOR	%	48.6%	48.6%	48.6%	48.6%	48.6%	48.6%	48.6%	48.6%
Design SOR	lb O_2/day	185,034	46,258	14,803	12,952	9,252	4,626	2,776	1,850
Hours per day aerating	hr	24	24	24	24	24	24	24	24
Design SOR	lb O_2/hr	7709.7	1927.4	616.8	539.7	385.5	192.7	115.6	77.1
Number of Trains/Cells		---	---	1	1	1	1	1	1
Length	ft	---	---	53.00	53.00	53.00	53.00	53.00	53.00
Width	ft	---	---	53.00	53.00	53.00	53.00	53.00	53.00
Side Water Depth	ft	---	---	17.00	17.00	17.00	17.00	17.00	17.00
Immersion Depth	ft	---	---	16.67	16.67	16.67	16.67	16.67	16.67
Volume	MG	8.573	2.143	0.357	0.357	0.357	0.357	0.357	0.357
Air Flow Required For Process	scfm	---	---	1696	1494	1077	562	296	180
Tank Flux Required For Mixing	scfm/ft2	---	---	0.10	0.10	0.10	0.10	0.10	0.10
Air Flow Required For Mixing	scfm	---	---	281	281	281	281	281	281
Design Air Flow	**scfm**	21,625	5,406	1,696	1,494	1,077	562	296	281
Membrane Area	sq ft	---	---	682	585	438	244	244	244
Operating Membrane Flux (Membrane Area)	scfm/ft2	---	---	2.49	2.55	2.46	2.31	1.22	1.15
Operating Tank Flux (Floor Area)	scfm/ft2	---	---	0.60	0.53	0.38	0.20	0.11	0.10
Bottom Coverage	%	---	---	24.3%	20.8%	15.6%	8.7%	8.7%	8.7%
SOTE At Operating Flux	**%**	---	---	35.0%	34.8%	34.5%	33.0%	37.6%	38.0%
Immersion Depth	ft	---	---	16.67	16.67	16.67	16.67	16.67	16.67
SOTE/ft of immersion	**%/ft**	---	---	2.1%	2.1%	2.1%	2.0%	2.3%	2.3%
ΔP Static	psig	---	---	7.23	7.23	7.23	7.23	7.23	7.23
ΔP Membrane	psig	---	---	0.81	0.81	0.80	0.80	0.73	0.72
ΔP Lateral Piping	psig	---	---	0.07	0.04	0.02	0.02	0.01	0.01
ΔP @ Top of Drop	psig	---	---	8.11	8.08	8.06	8.04	7.97	7.96
ΔP Fouling Allowance (engineer determined)	psig	---	---	0.50	0.50	0.50	0.50	0.50	0.50
ΔP @ at Top of Drop For Design	**psig**	8.61	8.61	8.61	8.58	8.56	8.54	8.47	8.46

Operating Conditions	Units	FUTURE AVERAGE	Train design	Cell design 1	Cell design 2	Cell design 3	Cell design 4	Cell design 5	Cell design 6
AOR	lb/day	70,000	17,500	5,600	4,900	3,500	1,750	1,050	700
alpha	fraction	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
beta	fraction	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Temperature	C	30	30	30	30	30	30	30	30
DO Concentration	mg/L	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Elevation	ft	50	50	50	50	50	50	50	50
AOR/SOR	%	42.3%	42.3%	42.3%	42.3%	42.3%	42.3%	42.3%	42.3%
Design SOR	lb O_2/day	165,537	41,384	13,243	11,588	8,277	4,138	2,483	1,655
Hours per day aerating	hr	24	24	24	24	24	24	24	24
Design SOR	lb O_2/hr	6897.4	1724.3	551.8	482.8	344.9	172.4	103.5	69.0
Number of Trains/Cells		---	---	1	1	1	1	1	1
Length	ft	---	---	53.00	53.00	53.00	53.00	53.00	53.00
Width	ft	---	---	53.00	53.00	53.00	53.00	53.00	53.00
Side Water Depth	ft	---	---	17.00	17.00	17.00	17.00	17.00	17.00
Immersion Depth	ft	---	---	16.67	16.67	16.67	16.67	16.67	16.67
Volume	MG	8.573	2.143	0.357	0.357	0.357	0.357	0.357	0.357
Air Flow Required For Process	scfm	---	---	1482	1305	941	490	258	158
Tank Flux Required For Mixing	scfm/ft2	---	---	0.10	0.10	0.10	0.10	0.10	0.10
Air Flow Required For Mixing	scfm	---	---	281	281	281	281	281	281
Design Air Flow	**scfm**	19,119	4,780	1,482	1,305	941	490	281	281
Membrane Area	sq ft	---	---	682	585	438	244	244	244
Operating Membrane Flux (Membrane Area)	scfm/ft2	---	---	2.17	2.23	2.15	2.01	1.15	1.15
Operating Tank Flux (Floor Area)	scfm/ft2	---	---	0.53	0.46	0.33	0.17	0.10	0.10
Bottom Coverage	%	---	---	24.3%	20.8%	15.6%	8.7%	8.7%	8.7%
SOTE At Operating Flux	**%**	---	---	35.9%	35.6%	35.3%	33.9%	38.0%	38.0%
Immersion Depth	ft	---	---	16.67	16.67	16.67	16.67	16.67	16.67
SOTE/ft of immersion	**%/ft**	---	---	2.2%	2.1%	2.1%	2.0%	2.3%	2.3%
ΔP Static	psig	---	---	7.23	7.23	7.23	7.23	7.23	7.23
ΔP Membrane	psig	---	---	0.79	0.79	0.79	0.78	0.72	0.72
ΔP Lateral Piping	psig	---	---	0.05	0.03	0.02	0.01	0.01	0.01
ΔP @ Top of Drop	psig	---	---	8.07	8.05	8.03	8.02	7.96	7.96
ΔP Fouling Allowance (engineer determined)	psig	---	---	0.50	0.50	0.50	0.50	0.50	0.50
ΔP @ at Top of Drop For Design	**psig**	8.57	8.57	8.57	8.55	8.53	8.52	8.46	8.46

Operating Conditions	Units	FUTURE MAX	Train design	Cell design 1	Cell design 2	Cell design 3	Cell design 4	Cell design 5	Cell design 6
AOR	lb/day	126,000	31,500	10,080	8,820	6,300	3,150	1,890	1,260
alpha	fraction	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
beta	fraction	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Temperature	C	30	30	30	30	30	30	30	30
DO Concentration	mg/L	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Elevation	ft	50	50	50	50	50	50	50	50
AOR/SOR	%	48.6%	48.6%	48.6%	48.6%	48.6%	48.6%	48.6%	48.6%
Design SOR	lb O_2/day	259,047	64,762	20,724	18,133	12,952	6,476	3,886	2,590
Hours per day aerating	hr	24	24	24	24	24	24	24	24
Design SOR	lb O_2/hr	10793.6	2698.4	863.5	755.6	539.7	269.8	161.9	107.9
Number of Trains/Cells		---	---	1	1	1	1	1	1
Length	ft	---	---	53.00	53.00	53.00	53.00	53.00	53.00
Width	ft	---	---	53.00	53.00	53.00	53.00	53.00	53.00
Side Water Depth	ft	---	---	17.00	17.00	17.00	17.00	17.00	17.00
Immersion Depth	ft	---	---	16.67	16.67	16.67	16.67	16.67	16.67
Volume	MG	8.573	2.143	0.357	0.357	0.357	0.357	0.357	0.357
Air Flow Required For Process	scfm	---	---	2511	2207	1596	835	453	272
Tank Flux Required For Mixing	scfm/ft2	---	---	0.10	0.10	0.10	0.10	0.10	0.10
Air Flow Required For Mixing	scfm	---	---	281	281	281	281	281	281
Design Air Flow	**scfm**	31,529	7,882	2,511	2,207	1,596	835	453	281
Membrane Area	sq ft	---	---	682	585	438	244	244	244
Operating Membrane Flux (Membrane Area)	scfm/ft2	---	---	3.68	3.77	3.64	3.43	1.86	1.15
Operating Tank Flux (Floor Area)	scfm/ft2	---	---	0.89	0.79	0.57	0.30	0.16	0.10
Bottom Coverage	%	---	---	24.3%	20.8%	15.6%	8.7%	8.7%	8.7%
SOTE At Operating Flux	**%**	---	---	33.1%	33.0%	32.6%	31.1%	34.4%	38.0%
Immersion Depth	ft	---	---	16.67	16.67	16.67	16.67	16.67	16.67
SOTE/ft of immersion	**%/ft**	---	---	2.0%	2.0%	2.0%	1.9%	2.1%	2.3%
ΔP Static	psig	---	---	7.23	7.23	7.23	7.23	7.23	7.23
ΔP Membrane	psig	---	---	0.88	0.89	0.88	0.86	0.77	0.72
ΔP Lateral Piping	psig	---	---	0.15	0.08	0.05	0.04	0.02	0.01
ΔP @ Top of Drop	psig	---	---	8.26	8.20	8.16	8.13	8.01	7.96
ΔP Fouling Allowance (engineer determined)	psig	---	---	0.50	0.50	0.50	0.50	0.50	0.50
ΔP @ at Top of Drop For Design	**psig**	8.76	8.76	8.76	8.70	8.66	8.63	8.51	8.46

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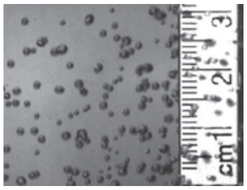
ATTACHMENT C
AEROSTRIP®
GENERAL INFORMATION

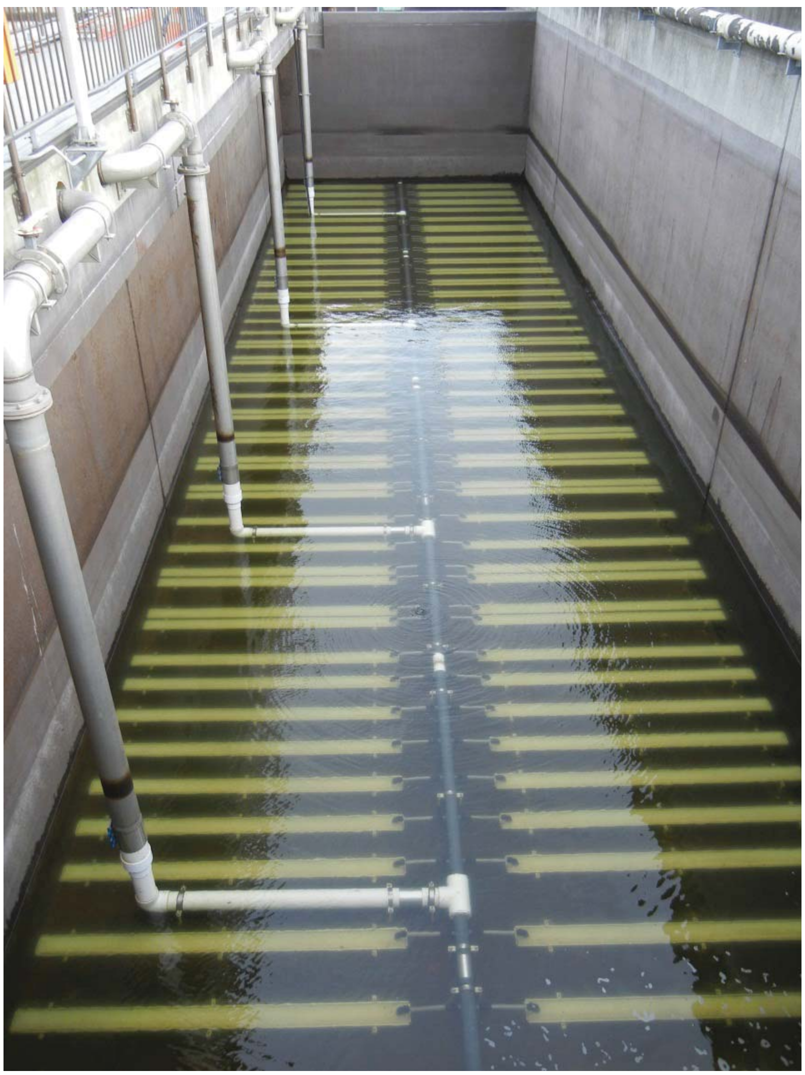


AEROSTRIP® Diffusers

The choice is yours.

AEROSTRIP® fine bubble diffusers are the most energy efficient and longest lasting aeration system available today.

Refer to the following pages for a more detailed description of the manufacturing, application, maintenance and energy savings associated with AEROSTRIP diffusers.



The choice is yours:

ditch the

or

turn off the *tube*

December 2011

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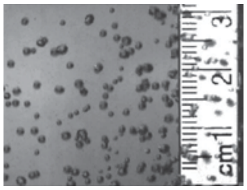
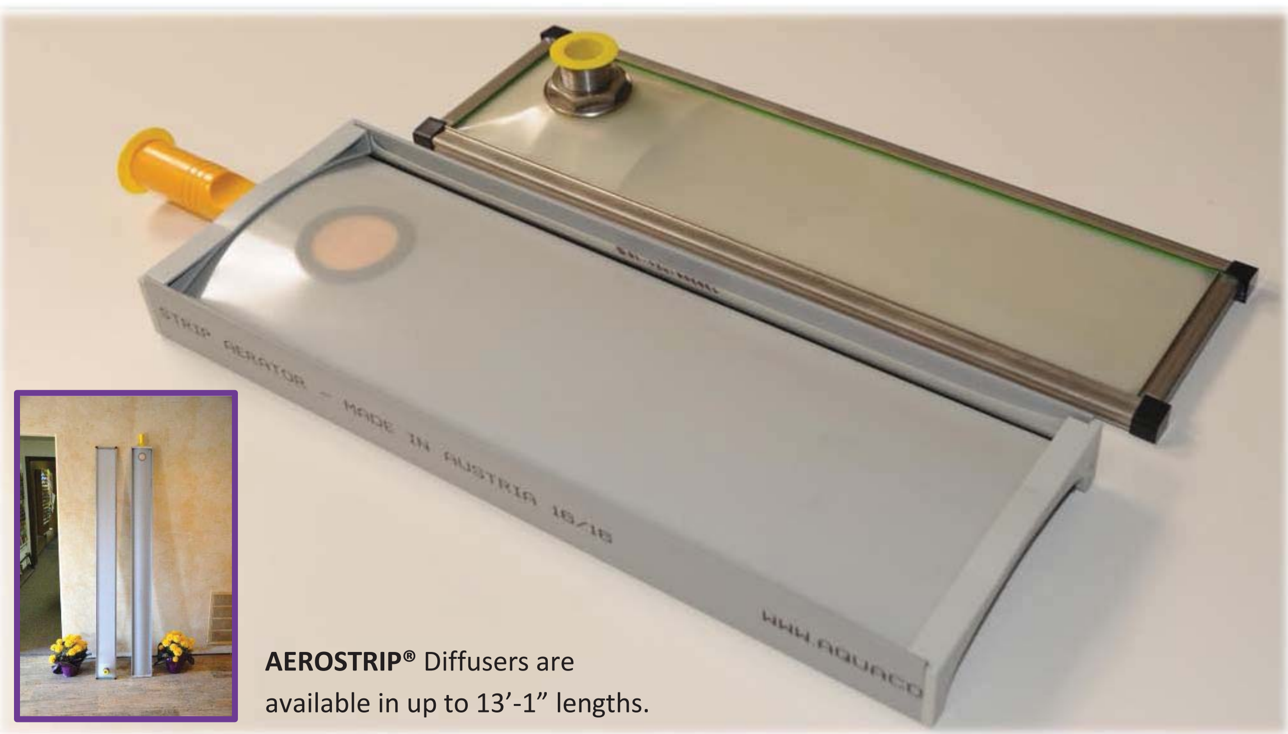
Bringing water to life



AEROSTRIP® Diffusers

Ditch the disc. Turn off the tube.

AEROSTRIP® diffusers are available in both 316SS ("T" type) and PVC ("Q" Type). "T" types are available in 15 (6-in) and 18 cm (7-in) widths. The width of the "Q" type is 18 cm (7-in). Both types use the same micro-perforated **polyurethane** membrane secured to either a stainless steel ("T" Type) or PVC ("Q" Type) base. Both "T" and "Q" types have identical oxygen transfer performance characteristics—**the best in the industry**.



AEROSTRIP® Diffusers are available in up to 13'-1" lengths.

Both models ("T" Type and "Q" Type) are available in 0.5 m (1'-8") incremental **lengths up to 4.0 m (13'-1")**. This means more active membrane area per diffuser for fewer diffusers and **easier installation** right on the basin floor.

All of the membrane area of **AEROSTRIP®** diffusers is in the horizontal plane and *none* is on the side or underside of the diffuser (as with tube designs). The 'strip' shape allows for significantly greater floor coverage than possible with disc diffusers. The **AEROSTRIP®** design, which includes proprietary membrane micro-perforation performed in **Austria**, allows Ovivo to provide the **most efficient fine bubble diffuser designs available** today.

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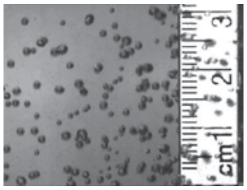
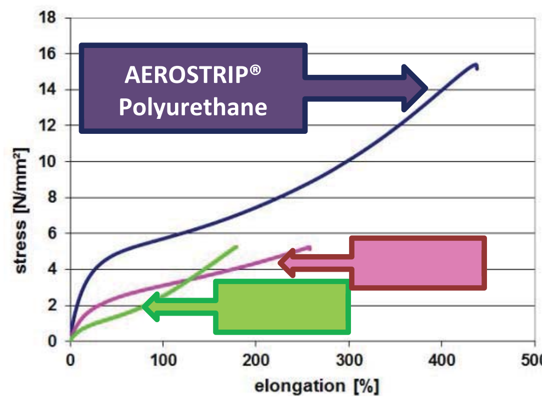
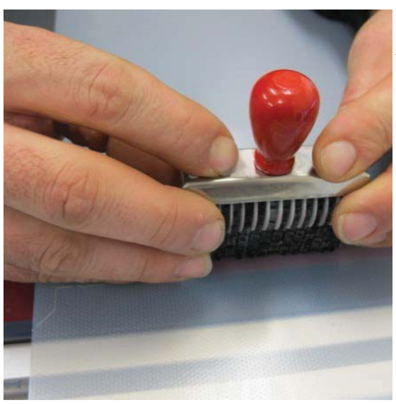


AEROSTRIP® Diffusers

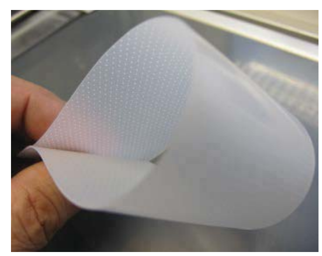
The Three 'M' s

MATERIAL. **AEROSTRIP®** diffusers use polyurethane membranes that use **no plasticizers or softeners**. Plasticizers used by other manufacturers leach into the wastewater in just a few years. Those other membranes become hard, have reduced oxygen transfer efficiencies, and require frequent replacement. **AEROSTRIP®** membranes retain their elasticity and performance over a **10-15 year** service life.

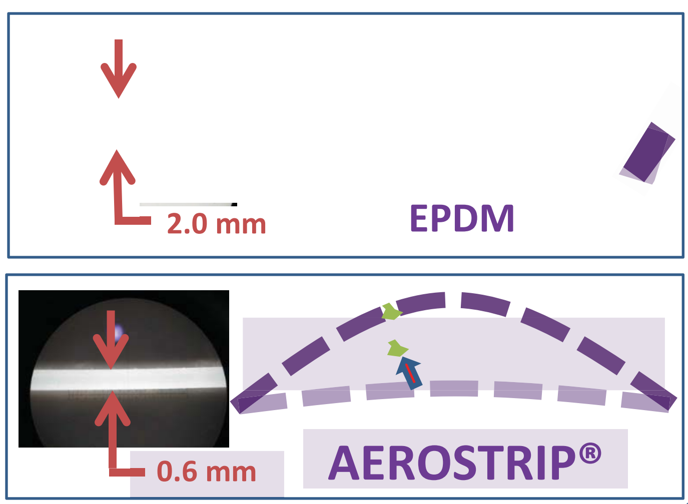




MANUFACTURING. **AEROSTRIP®** membranes are meticulously perforated with a **distribution** of micropores, allowing operation at **0.3 – 7.0 scfm/ft²**. The pores close when air flow ceases, allowing for intermittent **(ON/OFF)** operation with no backflow of mixed liquor. **Each individual diffuser** is pressure tested, visually inspected, operated submerged in clean water, and stamped with its own **unique serial number**.



MAINTENANCE. We use a simple **RELAX** cycle during which the air is shut off for several minutes per day. The thin profile of the **AEROSTRIP®** membrane relaxes onto the base in its unpressurized state, allowing **deposits to 'squeeze' out of the pores**. This is not possible with thicker EPDM membranes. Teflon coating used by other manufacturers is no substitute as the coating does not reach inside the pore walls.



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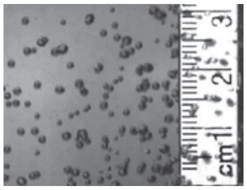
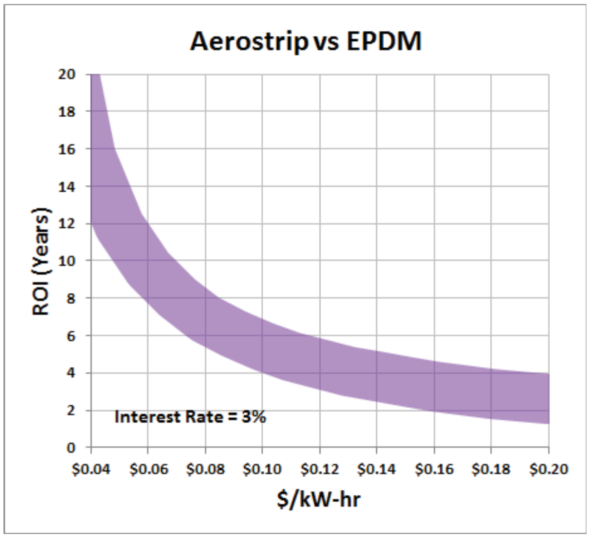


AEROSTRIP® Diffusers

What's Your ROI?

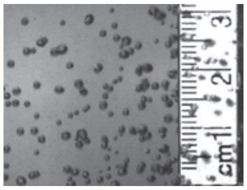


Wastewater treatment plants using **AEROSTRIP®** diffusers operate at a 20-40% higher SOTE than plants designed with EPDM fine bubble diffusers. We have documented that degradation of oxygen transfer efficiency over time is minimal. What does this mean for you? **A reduction of power bills** for many years for the most energy intensive process of your facility.

Contact Ovivo to determine the ROI for you facility.

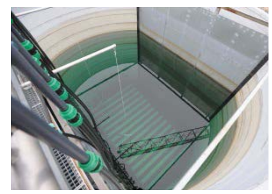
Perc Water selected **AEROSTRIP®** fine bubble diffusers after conducting an energy evaluation for the **3 MGD** Santa Paula, CA SBR. Energy savings were calculated to be **$15,000 per year** compared to other fine bubble systems. They concluded that the energy savings recovered the capital cost of retrofitting with **AEROSTRIP®** diffusers in just a few years.

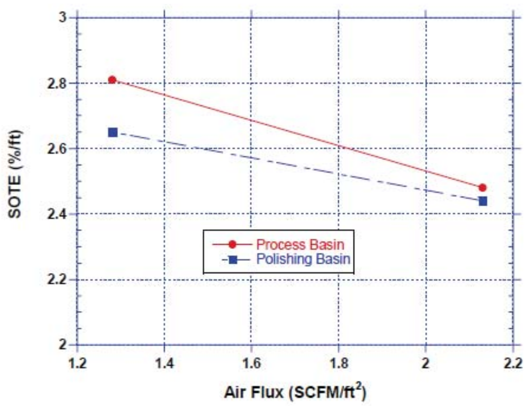
	Aerostrip Aeration	Other Fine Bubble	Other Course Bubble
Power (kW)	107.4	120.8	140.4
Savings (kWh/day)	0	- 321.6	*- 792.0*



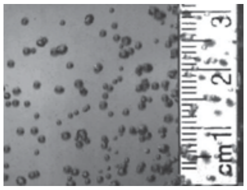
AEROSTRIP® Diffusers

Oxygen Transfer Testing - Case Histories





In 2012, off-gas testing was performed at the 11-year old Bremerton, WA facility. Following the off-gas testing, 18 original diffusers were removed from the front end of the tank (most severe service) and tested for clean water transfer efficiency in a 300 sq. ft. test tank. **<u>The average clean water transfer efficiency of the 11-year old diffusers was 2.0%/ft</u>** immersion! Material strength properties of the used membranes were excellent. The testing revealed an **alpha value of 0.5, extremely high rate 1.5-day SRT system**. The full report is available.



AEROSTRIP® Diffusers

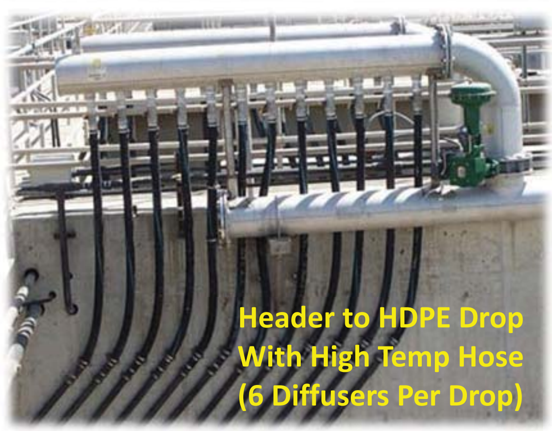
Yes, it fits

AEROSTRIP® fine bubble diffusers are manufactured in **varying lengths up to 13’-1”** and will fit in all wastewater applications—conventional, MBRs, oxidation ditches, SBRs—even sloped floors.

Connection “Q” Type to PVC Lateral
Diffusers Mounted Above Sloped Floor

Full Floor Coverage

Individual HDPE Drops
4 Diffusers Per Drop
(Red Pipe is RAS Line)



Header to HDPE Drop
With High Temp Hose
(6 Diffusers Per Drop)

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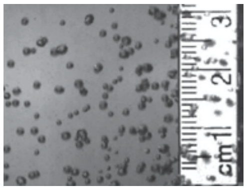

AEROSTRIP® Diffusers

FAQs - Frequently asked questions

1. <u>What is the size and the weight of an AEROSTRIP diffuser?</u>

   The diffuser width is 15 cm (5.9”) or 18 cm (7.1”). The length varies in 0.5 m (19.7”) increments between 0.5m (1.6 ft) and 4m (13.1 ft), special lengths by request. The largest AEROSTRIP diffuser (model T4-18) weight is approximately 27 lbs and has an aeration surface of 7.5 ft^2.

2. <u>What are the diffusers made of?</u>

   The base plate, peripheral strips and air connection are made from 316 Stainless Steel for the “T” type and are made from PVC for the “Q” type. The membrane is made from a proprietary thermoplastic polyurethane material selected to provide longevity as well as superior properties for fine bubble formation and backflow prevention.

3. <u>What is the range of the airflow capability of the Aerostrip diffuser?</u>

   The maximum airflow of the diffuser is 7.1 scfm/ ft^2. This allows for higher peak loads, for short periods of time. The minimum airflow is 0.3 scfm/ ft^2. This gives a 24:1 turndown range.

4. <u>How are the diffusers mounted inside the tank? What are the mounting or floor tolerances?</u>

   The diffusers can be installed directly on the tank bottom (grit removal, if required, is actually easier when the diffusers are installed very close to the bottom.) They can also be elevated if required. All diffusers attached to the same air header should be leveled within ±1“of each other. The diffuser should be level to ±0.5” along its length to ensure peak performance.

5. <u>How do we connect the diffusers to the main air supply distribution?</u>

   In large plants the air headers often run across the bottom of the tank feeding two rows of diffusers. Each diffuser is then connected to the air header by standard plastic tubing and fittings. Other possible configurations are available to meet your unique site constraints.

6. <u>Do we have to schedule the cleaning of the diffusers on a regular basis? How are they cleaned?</u>

   A large number of our references have the diffusers running in an on-off mode (e.g. for denitrification) and do not require any cleaning. For plants that are running at a constant air flow we recommend the use of a daily relaxing cycle, (i.e., turning the air flow off and releasing the air from the system for a few minutes and then restarting). This relaxing cycle squeezes deposits out of the pores before they have a chance to accumulate. For some plants where some chemical deposits build up even with the relax cycle, we have successfully dosed an organic acid feed into the air supply for a day or two every one to two years.

7. How long is the life expectancy for a membrane?

   The membrane has a life expectancy of 10-15 years for municipal wastewater applications. We have installations with AEROSTRIP diffusers running for longer than 15 years without membrane replacement.

8. Why is this system more efficient than other systems? Is it prone to clogging?

   Our diffusers produce very fine bubbles that rarely coalesce. The bubble release is very uniform across the surface. This is a result of superior membrane and perforation expertise that leads to increased efficiency. The shape adds to the efficiency when compared to other configurations. It is not prone to clogging as particles are squeezed out when the pores are closed, which occurs when the air is shut off. Our diffusers are preferred for on-off operation.

9. Have you performed any oxygen transfer efficiency tests with a third party independent institute?

   Yes, independent consultants have performed field testing on existing basins. In addition, we use clean water testing as a production quality control measure. For this purpose we have installed a test tank inside our production facility. Test reports are available upon request.

10. How high are the costs of your system, compared with other systems?

    The AEROSTRIP diffusers are energy efficient both for low and high-density systems. We are cost competitive when life cycle costs are considered, even at relatively low power rates.

11. Can we use the AEROSTRIP diffusers to upgrade an existing plant? Does this limit the existing mixing capability of the plant?

    The AEROSTRIP diffusers can be laid out in a very efficient manner and can be designed to avoid all existing obstacles. Existing old piping for old coarse bubble and old tubular diffusers can be utilized for substantial savings, as the ¾" fittings can be used to connect the new strip diffusers. The smaller the bubble size, the better the mixing for a given air flow. Mixing typically requires, 0.10 - 0.12 Scfm/ft^2 of bottom area with floor-mounted strip diffusers.

12. What is the safe-operating temperature range for the AEROSTRIP diffusers?

    The maximum operating temperature of the waste water is 95°F, which is acceptable for US municipal applications (AEROSTRIP installations are in FL, AZ, and CA). The water surrounding the diffuser must never be allowed to freeze. Temperature limits for storage are 23°F to 104°F. If the diffusers are to be stored outside at below freezing temperatures frost damage must be avoided. Membrane damage will occur with prolonged exposure to UV light. This is of special importance during storing and mounting. As soon as the mounting of diffusers is complete in one tank, the diffusers need to be covered with at least 3 ft of water. At low temperatures, aeration has to be in operation to avoid freezing. Multiple tank systems should be installed one tank after the other, in order to have a very short membrane exposure to UV light.

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13. Can we use the AEROSTRIP diffusers at a water temperature higher than 35°C (95° F)?

    We use our silicone membrane for higher water temperatures (theoretically up to 200°C = 392°F) and/or aggressive chemical environment. This membrane has the same high efficiency as the polyurethane membrane. The life expectancy of such a membrane is estimated to be 7-8 years. We have installed plants with these silicone membranes, installation list available upon request.

14. How much does the pressure drop increase during 15 years of operation?

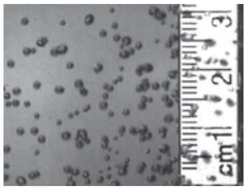
    AEROSTRIP membranes use no fillers or plasticizers. Reduction of flexibility or other deterioration of membrane performance with time will be minimal. Using the relaxing cycle described in #6 is typically sufficient to prevent significant clogging of pores over the life of the membrane. If required, the occasional dosing of organic acid in to the air supply line, also described in #6, will clear deposits such that the pressure drop will not increase by more than 0.2 psi even after 15 years of operation.

15. How many installations to you have?

    There are approximately 1,000 plants installed worldwide with over 50 installed in the USA.

16. Technical data of the membrane:

    Thickness of membrane: 0.024 inch (0.6 mm)
    Size of holes: 0.0079 inch (0.2 mm)
    Number of holes: app. 290/ $inch^2$ (45/cm^2)



AEROSTRIP® Diffusers

U.S. Installations

#	Plant	State	Quantity	Type			Membrane area	Year
					L	W	sq ft	
1	ABERDEEN	WA	246	T	3.0	18	1,430	2003
2	ABINGTON	NJ	450	Q	3.5	18	3,052	2008
3	ALDERWOOD WATER & WW	WA	334	T	3.5	18	2,265	2009
			16	T	3.0	18	93	2009
4	ANACORTES	WA	194	T	3.0	18	1,128	2011
5	ANGEL OF THE WINDS	WA	14	T	3.0	15	68	2004
6	ARLINGTON	WA	92	Q	4.0	18	713	2010
			80	Q	3.5	18	543	2010
			52	Q	3.0	18	302	2010
7	ATGLEN BOROUGH	PA	18	T	2.0	15	58	2001
8	BAKERSFIELD #3	CA	3,025	T	3.5	15	17,094	2008
9	BATH	PA	55	T	3.5	15	311	2003
10	BLAINE	WA	144	T	3.5	18	977	2009
			14	T	2.5	18	68	2009
11	BREMERTON	WA	293	T	3.0	15	1,419	2001
12	CAIRO	NY	12	T	3.5	15	68	1999
13	CAPE MAY	NJ	102	T	3.5	15	576	2003
			50	T	3.5	15	283	2004
14	CLOVIS	CA	172	T	3.5	18	1,166	2008
			30	T	2.5	18	145	2008
15	CUMBERLAND COUNTY	NJ	706	T	3.5	15	3,990	2001
16	EAST NORRITON	PA	165	T	4.0	15	1,066	2005
17	EPPING	NH	24	T	3.5	15	136	2001
18	FAIRVIEW	UT	47	T	3.5	18	319	2004
20	GIG HARBOR	WA	39	T	4.0	18	302	2008
			65	Q	4.0	18	504	2009

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21	GRANTS PASS	OR	299	T	4.0	15	1,931	2003
22	HALLSTEAD	PA	100	Q	4.0	18	775	2010
			17	Q	3.0	18	99	2010
24	INLAND EMPIRE RP#4	CA	840	T	3.5	18	5,696	2005
			2,040	T	3.5	18	13,834	2007
25	JOINT WWTF							2009
26	KARCHER CREEK	WA	20	T	3.5	18	136	2005
27	KINGS PARK	NY	208	T	3.5	18	1,411	2009
			17	T	2.0	18	66	2009
28	KISSIMMEE/ SOUTH BERMUDA	FL	296	T	4.0	15	1,912	2004
			601	T	3.0	15	2,911	2007
			95	T	3.0	15	460	2007
29	LA CENTER	WA	12	T	2.0	18	47	2009
			60	T	3.0	18	349	2009
30	LEHIGH ACRES	FL	30	T	3.5	15	170	2000
31	LINDA COUNTY	CA	325	T	4.0	15	2,099	2010
32	LIVE OAK	CA	200	T	4.0	18	1,550	2010
33	MILFORD/HOUSATONIC	CT	394	T	3.5	18	2,672	2008
			32	T	3.5	15	181	2008
34	MILLVILLE	NJ	575	T	3.0	15	2,785	2003
35	MOUNTAIN HOUSE	CA	540	T	3.5	18	3,662	2004
36	ONEIDA	NY	252	T	3.5	18	1,709	2005
			28	T	2.0	18	109	2005
			238	T	3.5	18	1,614	2010
			26	T	2.0	18	101	2010
37	ORLANDO/IRON BRIDGE	FL	980	T	4.0	18	7,595	2007
			128	T	3.5	15	723	2007
38	PALM BEACH COUNTY	FL	1,600	T	4.0	15	10,333	2004
			205	T	4.0	15	1,324	2009
			800	T	4.0	15	5,167	2009
			400	T	4.0	15	2,583	2010
39	PARSIPPANY	NJ	336	Q	4.0	18	2,604	2010
			840	Q	3.0	18	4,883	2010
			56	Q	2.5	18	271	2010
			48	Q	2.0	18	186	2010
			60	Q	1.5	18	174	2010
40	POINCIANA #2/5	FL	465	T	3.5	18	3,153	2009
			30	T	3.0	15	145	2009

41	PORT OF SUNNYSIDE	WA	485	T	4.0	18	3,759	2004
			70	T	4.0	18	543	2010
42	PORT ORCHARD	WA	72	T	3.0	15	349	2003
			63	T	3.0	18	366	2005
			10	T	2.0	18	39	2005
43	RENO / STEAD	NV	50	T	3.5	18	339	2003
			335	T	3.0	15	1,623	2005
44	RICHLAND	WA	298	T	4.0	18	2,310	2005
			86	T	3.5	18	583	2005
			55	T	2.0	18	213	2005
			195	T	4.0	18	1,511	2010
			70	T	3.5	18	475	2010
			395	T	3.0	18	2,296	2010
			20	T	2.0	18	78	2010
45	ROLLING HILLS	CA	44	T	3.5	18	298	2004
46	ROME	NY	590	T	3.0	18	3,429	2008
			14	T	2.0	18	54	2008
47	ROTONDA WRF	FL	176	T	4.0	18	1,364	2008
			10	T	3.0	18	58	2008
			1	T	2.5	18	5	2009
			11	T	4.0	18	85	2009
48	SAND HILL ROAD	FL	500	T	3.5	18	3,391	2005
			250	T	3.5	18	1,695	2010
49	SANTA PAULA	CA	215	Q	3.5	18	1,458	2009
50	SENECA/NIAGARA FALLS	NY	158	T	4.0	18	1,225	2006
			3	T	3.5	18	20	2006
			3	T	1.5	18	9	2006
51	SIMI VALLEY	CA	750	T	4.0	15	4,844	2004
			15	T	4.0	15	97	2009
52	SOMERTON	AZ	144	Q	2.5	18	698	2011
53	SOUTH TRUCKEE MEADOWS	NV	369	T	3.5	15	2,085	2001
54	SPOKANE	WA	458	T	2.0	18	1,775	2010
			40	T	1.5	18	116	2010
			20	T	1.0	18	39	2010
55	SURPRISE / ASANTE	AZ	170	T	3.5	18	1,153	2006
			5	T	2.0	18	19	2006
								2007
			245	T	4.0	18	1,899	

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56	TENINO							2009
57	THREE RIVERS	OR	25	T	3.5	18	170	2007
			2	T	2.0	18	8	2007
58	TREASURE LAKE	PA	78	T	4.0	15	504	2002
59	TROY	MO	26	T	3.5	18	176	2006
			10	T	3.0	18	58	2006
60	VALLEY SANITARY DISTRICT	CA	693	T	3.5	18	4,699	2007
61	WASHINGTON BEEF	WA	300	T	4.0	18	2,325	2010
			300	T	3.5	18	2,034	2010
62	WINLOCK	WA	57	T	3.5	18	387	2007
63	YAKAMA LEGENDS	WA	17	T	4.0	18	132	2007

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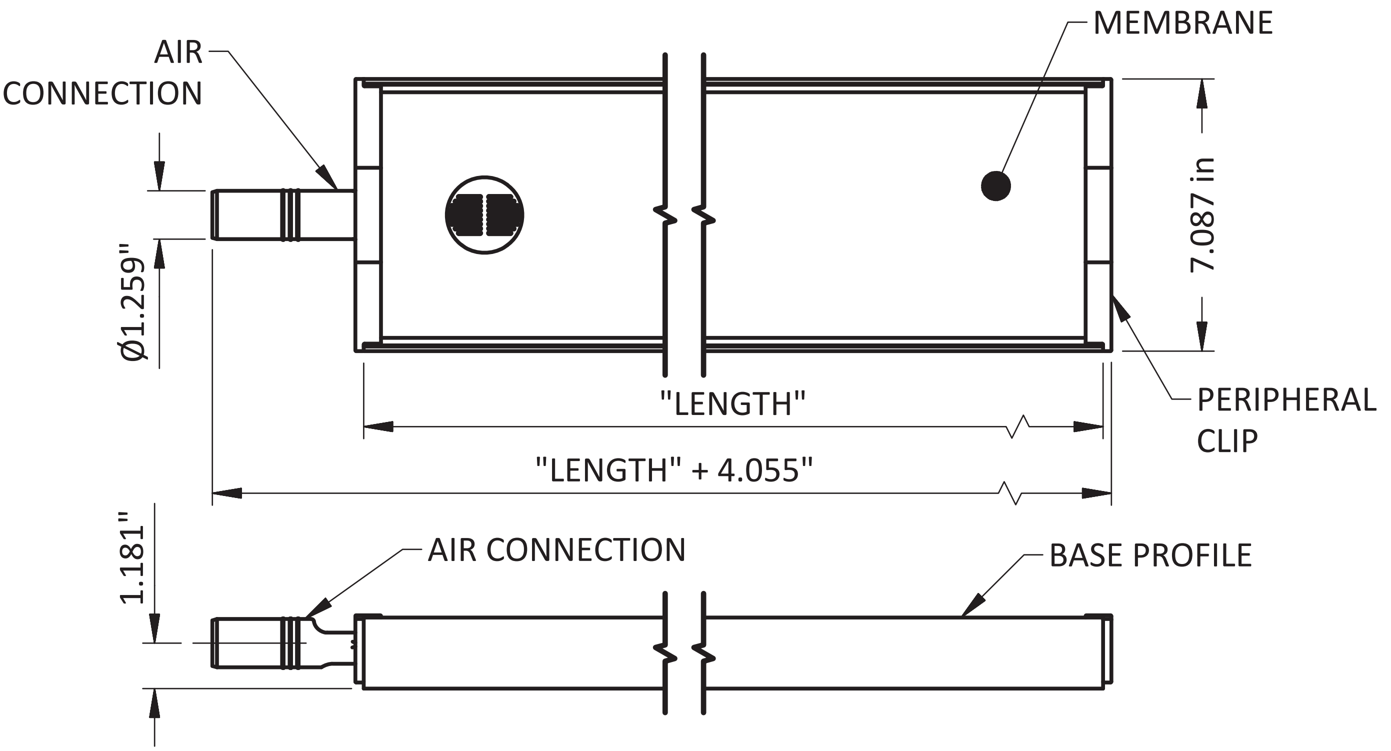
AEROSTRIP® Diffusers
Q Type



Aerostrip Type Q				
TYPE	LENGTH (FT)	MEMBRANE AREA (sq. ft)	WEIGHT (lbs)	AIR FLOW RANGE (SCFM)*
Q0.5-18	1.64	0.94	3.30	0.27 - 6.58
Q1.0-18	3.28	1.87	5.95	0.55 - 13.16
Q1.5-18	4.92	2.81	8.60	0.82 - 19.78
Q2.0-18	6.56	3.74	11.02	1.10 - 26.33
Q2.5-18	8.20	4.69	13.67	1.37 - 33.02
Q3.0-18	9.84	5.62	16.31	1.65 - 39.56
Q3.5-18	11.47	6.56	18.74	1.92 - 46.18
Q4.0-18	13.13	7.49	21.38	2.19 - 52.73

* INTERMITTENT OPERATION WITH PERIODS OF ZERO FLUX POSSIBLE DUE TO ADVANCED PERFORATION TECHNOLOGY OF AEROSTRIP. CONSULT FACTORY FOR DETAILS RELATING TO STATED OPERATING RANGES.

MATERIALS

BASE PROFILE: PVC
PERIPHERAL CLIPS: PVC OR 316 SS
MEMBRANE: POLYURETHANE (PUR)

AIR CONNECTION: NIPPLE OUTER DIAMETER 1.259"; PVC
FASTENERS: 304 SS

REVISION DESCRIPTION	EN/ECO	BY	CHECK'D	DATE	REV
INITIAL RELEASE	-	-	-	-	A

A

THIRD ANGLE PROJECTION

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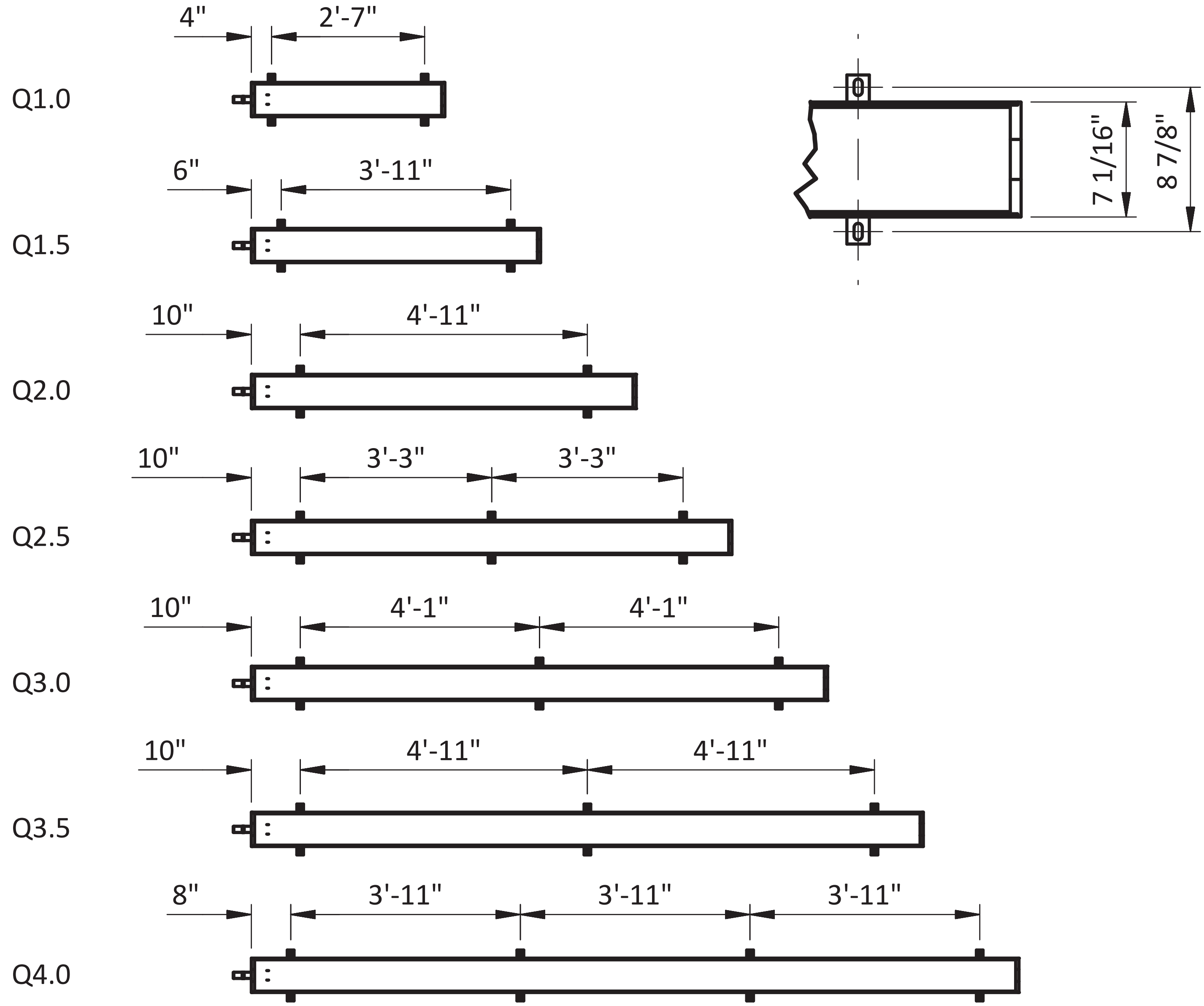
AEROSTRIP TYPE Q
STRIP AERATOR

REF. FROM	BUL. 390	DO NOT SCALE PRINTS
DATE (mm/dd/yyyy)	1/10/2012	WORKMANSHIP STANDARD ES0001 APPLIES
DRAWN	DJN	ORIGINAL S.O.
CHECK'D	MTW	STANDARD

DWG. NO. **BUL 390.0** SHEET 1 OF 1 REV **A**



NUMBER OF CLIPS AND CLIP LOCATIONS

REVISION DESCRIPTION	EN/ECO	BY	CHECK'D	DATE	REV
INITIAL RELEASE	-	-	-	-	A

A

THIRD ANGLE PROJECTION

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AEROSTRIP TYPE Q DIFFUSER FASTENING & CLIP LOCATIONS

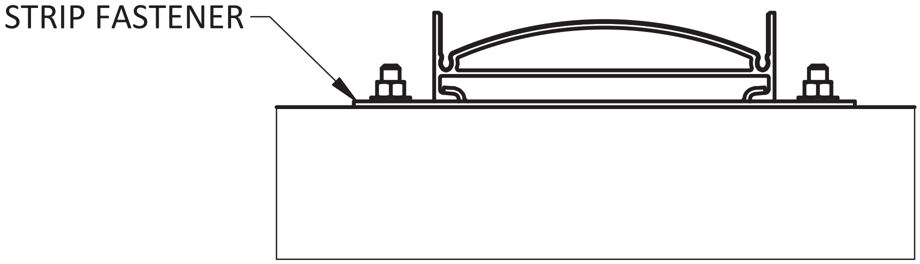
REF. FROM	BULL 392	DO NOT SCALE PRINTS
DATE (mm/dd/yyyy)	1/17/2012	WORKMANSHIP STANDARD ES0001 APPLIES
DRAWN	DJN	ORIGINAL S.O.
CHECK'D	DPH	STANDARD

DWG. NO. **BULL 392-O**

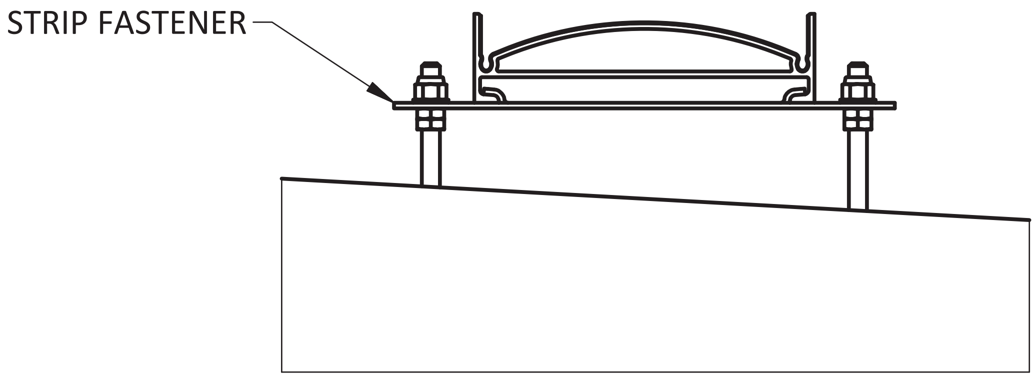
SHEET **1** OF **2**

REV **A**

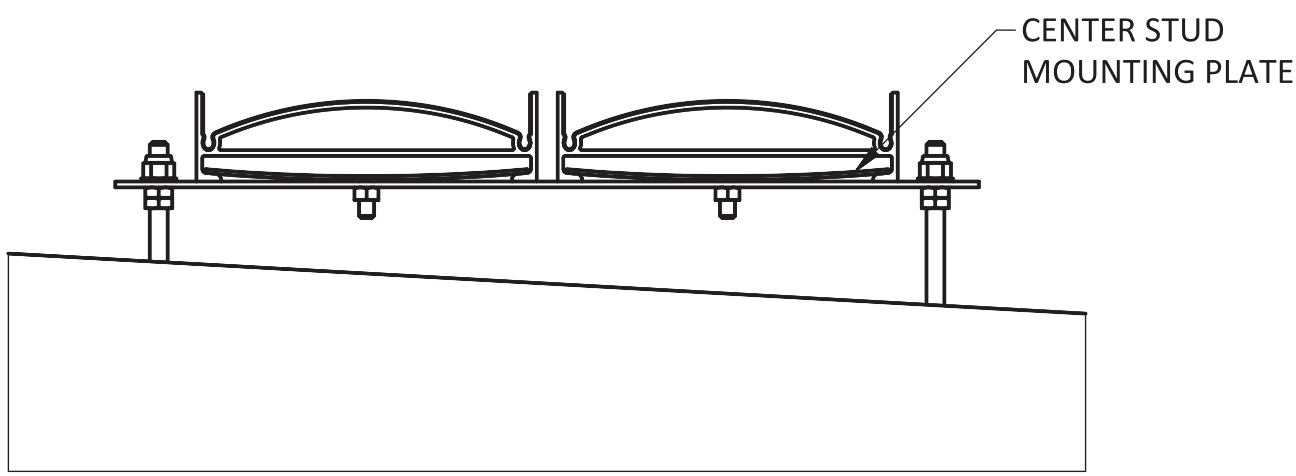
STANDARD MOUNTING OPTIONS



SINGLE DIFFUSER FLAT FLOOR



SINLGE DIFFUSER SLOPED FLOOR



MULTIPLE DIFFUSERS SLOPED FLOOR

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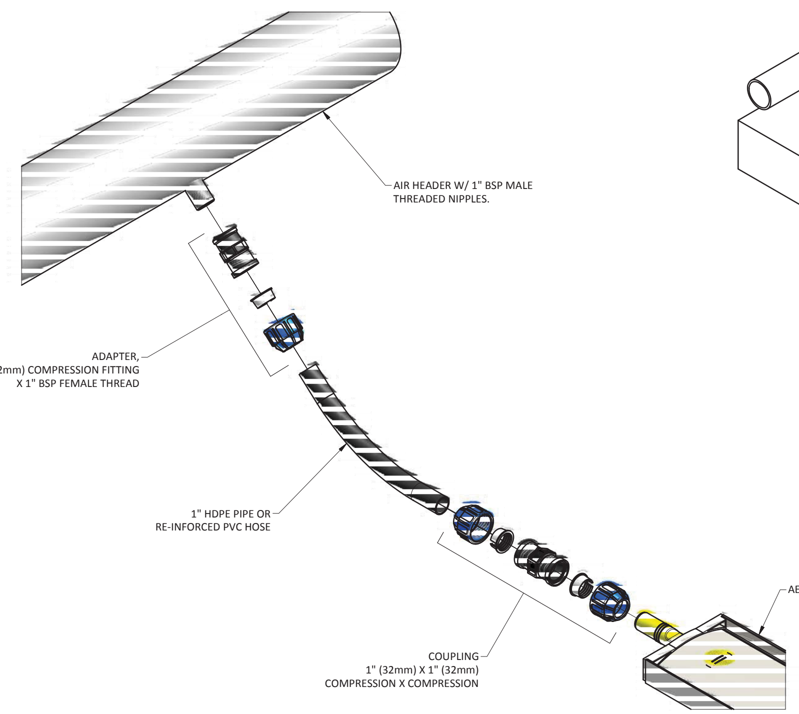

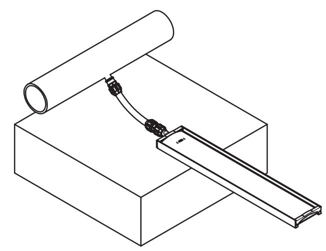

INITIAL RELEASE	-	-	-	-	A
REVISION DESCRIPTION	EN/ECO	BY	CHECK'D	DATE	REV

THIRD ANGLE PROJECTION

REF. FROM		DO NOT SCALE PRINTS
DATE (mm/dd/yyyy)	11/2/2011	WORKMANSHIP STANDARD ES0001 APPLIES
DRAWN	DJN	ORIGINAL S.O.
CHECK'D	MTW	STANDARD

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STANDARD CONNECTION
TYPE Q
AEROSTRIP DIFFUSER

DWG. NO.	SHEET	REV
TYPE Q	1 OF 1	A

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Q-type Diffusers Mounted Above Floor — Parsippany, NY, USA

Type Q Diffuser Installation — Parsippany, NY, USA

OTHER POSSIBLE INSTALLATION OPTIONS

Photos Show T Type But All Options Are Also Applicable to Q Type

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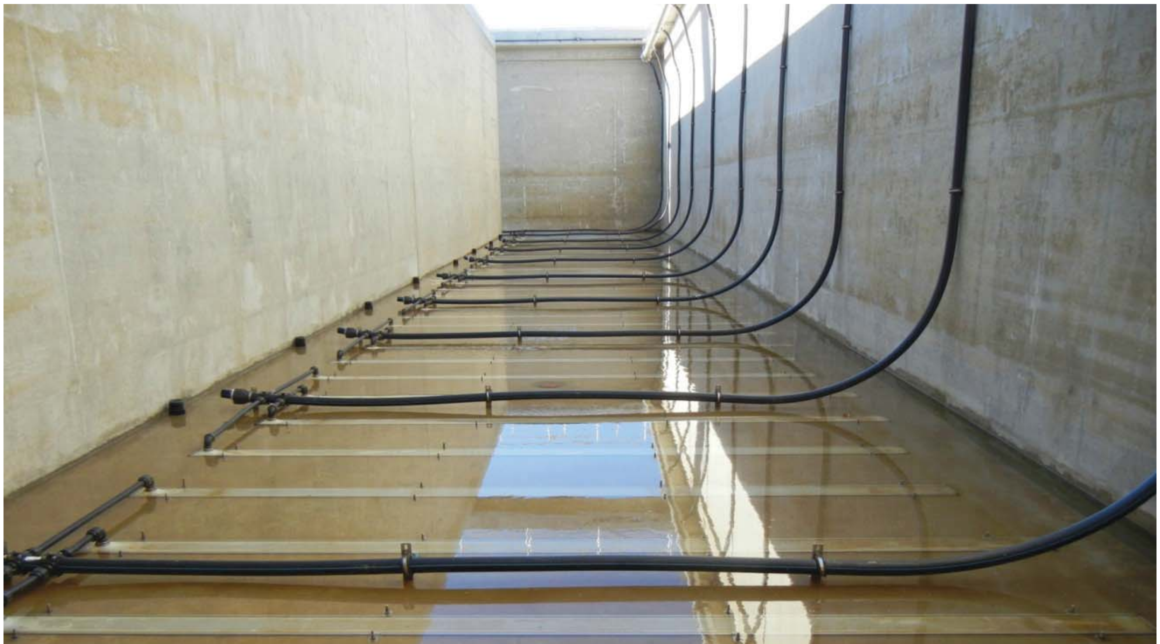

T-Type Diffusers
HDPE Drop-Pipes

Linda County, CA, USA

HDPE Drop and Connections

Linda County, CA, USA

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HDPE Drop-Pipes on Individual Valves

Inland Empire, CA, USA

T-Type Diffusers

Inland Empire, CA, USA

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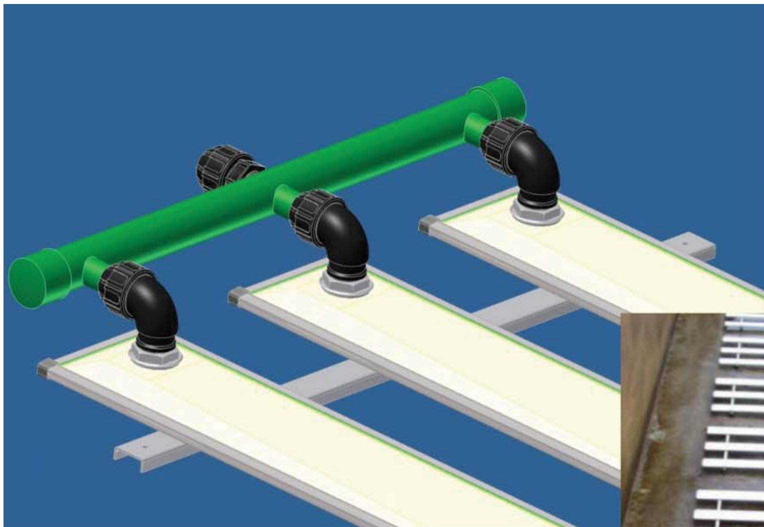


T-Type Diffusers
HDPE Drop, PVC Manifold

Europe

Removable Frame

Europe

AEROSTRIP® References with Contact Information:

Conventional Plants

Bremerton, WA (5 MGD)
Oldest Operating US Installation (2001)
Off Gas and SOTE Test of 11-Year Old Diffusers by Stenstrom
280 each T3.015 Diffusers Installed
Owner: Larry Willman, chief operator, (360) 473-5450

Abington, PA (5 MGD)
Oldest Q Type US Installation (2007)
450 each Q3.5-18 Diffusers Installed
Owner: Robert S. Leber, director, (215) 884-8329

Inland Empire, CA RP#4
Experience with both AEROSTRIP and the PARKSON panels within district (2005)
2,880 each T3.5-18 Diffusers Installed
Owner: Jeff Noelte, PE, Senior Engineer, Inland Empire Utilities Agency, (909) 993-1912

Bakersfield, CA Plant #3 (32 MGD)
Largest U.S Installation (2008)
SOTE Test By Stenstrom
3,025 each T3.5-15 Diffusers Installed
Engineer: Parsons, Madan Arora, (626) 440-2000

Rome, NY (9 MGD)
Retrofit Under an Energy Contract (2008)
590 each T3.0-18 Diffusers Installed
Owner: Dave Marino, (315) 838 0437
Bill Baynes, chief operator, (315)-339-7775 x 223

Sequencing Batch Reactors (SBR's)

Port of Sunnyside, WA
485 each T4.0-18 diffusers Installed
106 ft diameter; 23.5 ft SWD
SOTE Test Available by Gerry Shell – Full Scale

Engineer:	AECOM (Earth Tech)
Owner:	Bob Farrell
	(509) 839-3187

Washington Beef, WA
600 (300 T4.0-18 + 300 T3.5-18) diffusers Installed

Owner:	Sherry Byers-Eddy
	(509) 865-2121
Engineer:	BHC Consultants
	Jeff Howard
	(206) 372-8162
Manufacturer:	Ashbrook
	Chad Dannemann
	(281) 985-4455

Design/Build/Operate

PACE/Perc is an engineering / operations firm in CA/AZ that has used Aerostrip on several of their plants in Arizona and California, including experience with Q Type at their Santa Paula facility.

Contact:	Juergen Nick, PE
	Vice President - Design & Engineering
	PERC Water Corporation
	602-275-8066 x 104 – Direct

Offices of National Engineering Firms that have used AEROSTRIP:

Black and Veatch - Inland Empire, CA - Cindy Wallis-Lage was involved

CDM Smith - Rome, NY; Parsippany/Troy Hills, NY
Al Saikkonen: (315) 434-3268
Nancy Vigneault: (315) 434-3247

CH2MHill - Spokane, WA
Bryan Youker: (541) 758-0235

Brown and Caldwell - Richland, WA; Gig Harbor, WA; Alderwood, WA; Blaine, WA; Central Kitsap, WA
Patricia Tam: (206) 749-2264

Kennedy Jenks
LA Center, WA; Arlington, WA; Linda County, CA

MWH
Yorkshire Water, UK, Simi Valley, CA, Steve Palmer

Parsons - Bakersfield, CA
Madan Arora - (626) 440-2000

AECOM - Milford, CT
Kenneth A. Bradstreet, P.E. - (860) 263-5787
James J. Marx, PE - (202) 787.2514

Port of Sunnyside, WA
Chen-wei Shen, P.E. was present for OTE Testing
Earthtech Office

TETRA TECH, INC.

ATTACHMENT G
PARKSON MEMBRANE PANEL PROPOSAL
(OPTION 8)

1401 West Cypress Creek Road
Fort Lauderdale, FL 33309-1969
Phone 954.974.6610
Fax 954.974.6182

HiOx® UltraFlex Aeration Panel Budget Proposal

To: John Toomey	**Date:** 1/15/2013
Company: Tetra Tech	**From:** Rakesh Desai
Phone:	**Phone:** 954-917-1818
Email: John.Toomey@tetratech.com	**Email:** rdesai@parkson.com
# Pages:	**cc:** Paul Mahoney, Barry Gregoire
Subject:	

Mr. John Toomey

Thank you for your interest in our HiOx® UltraFlex Aeration Panels and for your invitation to preliminarily size the aeration system for the Tampa DAR, FL project. Please note that this design can always be adjusted per your requirements.

The new HiOx® UltraFlex Aeration System is a breakthrough in the diffused aeration market, offering the following advantages to the Owner and the Engineer:

- Our standard HiOx® UltraFlex Aeration Panel is 4' wide x 12' long and weights only 65 pounds, making it considerably easy to handle and install.
- Each HiOx Panel typically has its own dedicated air feed line. Isolating ball valves on each dedicated air feed line makes isolation of HiOx panel very easy.
- The rectangular shape of the panel allows a great deal of diffuser membrane area on the basin floor – much more than alternative diffuser designs – while still allowing for enough room to easily walk around the diffusers for maintenance, etc.
- Larger membrane area leads to substantially lower flux rates (air flow per active membrane area) and smallest bubbles (~1 mm), resulting in high energy-efficiency.

- Each HiOx panel is individually tested for air distribution and head-loss before shipping to the jobsite.
- Highly durable membrane with extended life of ten or more years
- Membrane replacement is quick (1 to1.5 man-hours/ panel) & easy.

The following parameters have been used for designing the HiOx UltraFlex Aeration System:

Basis of Design							
Parameter	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone6**	**Notes**
# of Aeration Basins	4	4	4	4	4	4	Given
Aeration Basin Dimensions (ft)	53 x 53	53 x 53	53 x 53	53 x 53	53 x 53	53 x 53	Given
Max Wastewater Temperature (°C)	30						Assumed
Site Elevation (ft)	20						Assumed
SWD (ft)	17						
Diffuser Depth (ft)	16.5						
DO (mg/L)	2	2	2	2	2	2	Assumed
Alpha (α)	0.55	0.55	0.55	0.55	0.55	0.55	Assumed

Design (Current Flow)							
Parameter	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone6**	**Notes**
Current Average Flow (MGD)	56	56	56	56	56	56	Given
AOR (lbs O_2/day)-current	16000	14000	10000	5000	3000	2000	Calculated
SOR (lbs O_2/day)-current	38101	33339	23813	11907	7144	4763	Calculated
Proposed # of panels	108	100	76	60	40	28	412 total
HiOx Model	4' x 12'	4' x 12'	4' x 12'	4' x 12'	4' x 12'	4' x 12'	
Effective membrane area (ft^2)	4180.68	3871	2941.96	2322.6	1548.4	1083.88	
Membrane Area Bottom Coverage (%)	37	34	26	21	14	10	
Estimated SOTE (%)	34	34	31	37	34	34	
Estimated Air Requirement (SCFM)	4476	3978	3106	1292	853	570	**Zone 4-6 mixing limited**
Estimated Air Flux Rate (SCFM/ft^2)	1.07	1.03	1.06	0.56	0.55	0.53	
Estimated In-basin pressure drop* (psig)	8.5	8.5	8.5	8.3	8.3	8.3	
Estimated HP requirement* (HP)	220	195	152	62	41	27	
Std. Aeration Eff. (SAE)* (lbs.O_2/kWh)	9.7	10	9	11	10	10	
Blower's Efficiency (%)	65	65	65	65	65	65	

Design (Future Flow)							
Parameter	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone6**	**Notes**
Future Average Flow (MGD)	96	96	96	96	96	96	
AOR (lbs O_2/day)-future	22400	19600	14000	7000	4200	2800	Calculated
SOR (lbs O_2/day)-future	53342	46674	33339	16669	10002	6668	Calculated
Proposed # of panels	108	100	76	60	40	28	412 total
HiOx Model	4' x 12'	4' x 12'	4' x 12'	4' x 12'	4' x 12'	4' x 12'	
Effective membrane area (ft^2)	4181	3871	2942	2323	1548	1084	
Membrane Area Bottom Coverage (%)	37	34	26	21	14	10	
Estimated SOTE (%)	34	34	31	30	27	27	
Estimated Air Requirement (SCFM)	6266	5569	4348	2201	1469	993	**Zone 6 mixing limited**
Estimated Air Flux Rate (SCFM/ft^2)	1.50	1.44	1.48	0.95	0.95	0.92	
Estimated In-basin pressure drop*	8.7	8.7	8.7	8.4	8.4	8.4	
Estimated HP requirement* (HP)	315	279	218	107	72	48	
Std. Aeration Eff. (SAE)* (lbs.O_2/kWh)	9.5	9	9	8.7	8	8	
Blower's Efficiency (%)	65	65	65	65	65	65	

* -Estimated based on in-basin piping and aeration panel assembly. Engineer to account for any losses associated with yard piping to the blowers.

Based on the preliminary sizing, the budget price for these 412 HiOx® UltraFlex Aeration Panels with all in-basin piping (including isolation ball valve) and startup service is:

Budget Price ………………………………………… **$970,000**
FOB shipping point with freight allowed to the site.
Taxes excluded

Please note that the use of a lesser number of HiOx® UltraFlex Aeration Panels would result in a lower capital cost; however, additional air would be required.

We are including our individual air feed system that provides ultimate operating flexibility and simplicity. Each Aeration Panel has an individual isolation valve located at the top of the individual drop. There is never any reason to dewater a basin unless it is a scheduled maintenance event. No other fixed diffuser system can offer this level of operational reliability.

Maintenance for the HiOx® UltraFlex Aeration Panel involves a simple membrane-flexing program performed on a weekly basis.

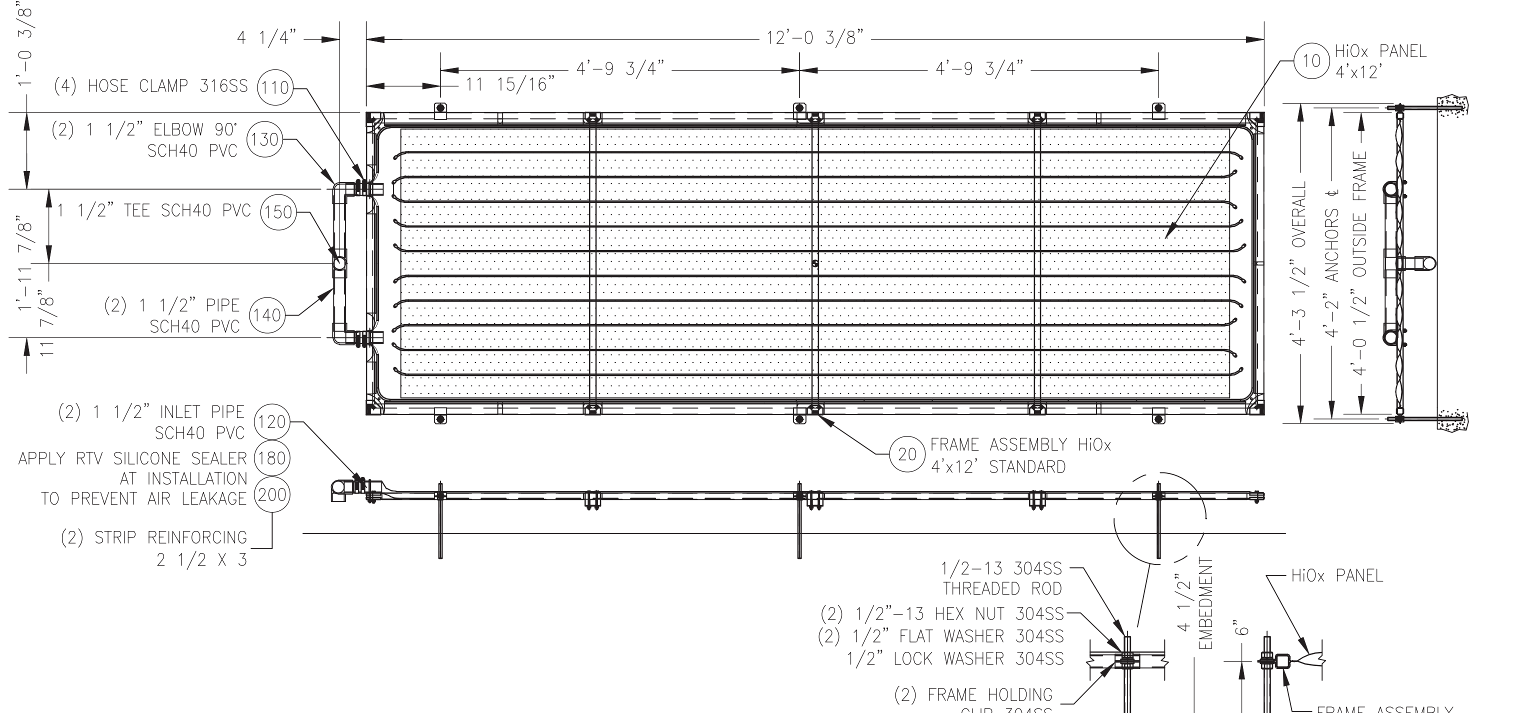
The installation time for the HiOx Panel is much less than for the traditional fine bubble systems. The total installation time for the panels, all the in-basin piping and anchors will be between 1 to 2 man-hours per panel. The fact that there are much fewer diffusers, piping and anchors to install, results in significant cost savings for the owner.

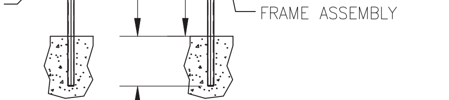
Furthermore, there are significantly fewer membranes to maintain with the HiOx Aeration Panel system than with the fine bubble systems. The result is significant maintenance costs savings. The HiOx Aeration Panel has a proven 10 year membrane life. No other membrane has this experience and longevity. Most EPDM membrane experience demonstrates a life of 3-5 years. Off gas testing of the Aeration Panel demonstrates that the membranes have essentially the same efficiency as a new membrane after almost 10 years of operation.

Please review this design information, and feel free to contact me with any questions you may have on the subject.

Best Regards,

Rakesh Desai
Applications Engineer





NOTES:
1. APPLY RTV SILICONE SEALER TO INLET PIPE BEFORE INSTALLING HOSE CLAMPS.
2. DO NOT PINCH OR CUT PANEL INLET WITH U-BOLT.
3. CARE MUST BE TAKEN WHEN INSTALLING PVC PIPE FITTINGS; WET PVC GLUE WILL DAMAGE MEMBRANE.
4. TORQUE ITEM #110 TO 50 TO 60 IN-LBS AND INLET U-BOLTS TO 60 TO 70 IN-LBS.
5. MOUNTING ANCHORS SHOWN FOR INFORMATION; REFER TO PROJECT AIRFEED ASSEMBLY FOR DETAILS.
6. DO NOT GLUE ITEM #150 AT ASSEMBLY; LOCATE AND GLUE TEE AT INSTALLATION.

ONLY USED THIS MOUNTING ARRANGEMENT FOR NEW INSTALLATIONS & RETROFIT OF EXISTING PARKSON TOP SEAL PVC AERATION PANELS SHOWN ONE ANCHOR ARRANGEMENT REQUIRE SIX PER PANEL

REV	DESCRIPTION	DATE	BY
6	UPDATED TITLE	9/8/09	AJS
5	MODIFIED ASSY WIDTH, INLET ℄ & WELD DIE	7/7/09	JFA
4	MODIFIED PER LATEST DESIGN OF 11/21/08	12/9/08	Gm-j
	MODIFIED INLET PIPES ADDED REINFORCE STRIPS		
	ADDED NOTE 2A & ITEM 200		

__ PRELIMINARY __ APPROVAL
__ INFORMATION X CERTIFIED

THIS DRAWING IS LIMITED TO FUNCTIONAL DESIGN, GENERAL ARRANGEMENT AND CLEARANCE. NO RESPONSIBILITY IS ACCEPTED BY PARKSON CORPORATION FOR OTHER DIMENSIONS, QUANTITIES, OR COORDINATION WITH OTHER EQUIPMENT OR DRAWINGS EXCEPT AS STATED IN PURCHASE ORDER.

DRAWN BY	DATE
JFA	5/22/07
CHECKED BY	DATE
JSD	5/22/07
SCALE	SIZE
1 : 16	B

Parkson™

PROJECT NAME
STANDARD
HiOx® UltraFlex AERATION PANEL
PARKSON
FT. LAUDERDALE, FL

REFERENCE INFORMATION

TITLE
HiOx® UltraFlex AERATION PANEL ASSEMBLY
4x12 – 4.2 PITCH DUAL INLETS
1x1x16GA 304SS FRAME

DRAWING NO 0010790-01
REV 6
SHEET 1 OF 1

Parkson
Treating Water Right

HiOx® *Aeration Panel Reference List - N. America*

HiOx®

	Installation and Contact	Location	Size of plant	# of panels	Model	Type	Start-up	Engineer of Record
1	**Woodridge WWTP** Mr. Greg Wilcox, Director of Public Works Mr. Bill Kennedy, Chief Operator 630-985-7400	**DUPAGE COUNTY, IL**	11 MGD	106 panels 104 panels	4' x 12' 4' x 12'	SS SS	1989 1991	Consoer, Townsend Chicago, IL
2	**FAIRFIELD, OH** Mr. Drew Young, Plant Superintendent 513-867-5322	**FAIRFIELD, OH**	4 MGD	120 panels	4' x 12'	SS	1989	GRW Engineers Lexington, KY
3	**SOUTH KINGSTOWN, RI** Mr. Bernie Bishop, Plant Superintendent 401-788-9772	**SOUTH KINGSTOWN, RI**	5 MGD	144 panels	4' x 12'	SS	1990	Keyes Associates Lincoln, RI
4	**Chino Basin RP-2** Inland Empire Utilities Agency Mr. Patrick Shields, P.E., Operations Manager 909-947-4131	**CUCAMONGA, CA**	1 MGD	21 panels	4' x 12'	SS	1990	Plant
5	**CEDAR KEY, FL** Mr. James McCain, Plant Superintendent 352-543-5285	**CEDAR KEY, FL**	0.75 MGD	16 panels	4' x 12'	SS	1992	Stearns & Wheler Tampa, FL
6	**YORKVILLE - BRISTOL, IL** Mr. Ralph Pfister, Plant Superintendent 630-553-7657	**YORKVILLE - BRISTOL, IL**	1 MGD	32 panels	4' x 12'	SS	1993	Plant
7	**Marsh Creek WWTP** Mr. Gordon Eddington, Plant Superintendent 315-789-8040	**GENEVA, NY**	3 MGD	60 panels	4' x 12'	SS	1993	O'Brien & Gere Engineers New York
8	**Bergen Point WWTP** Suffolk County DPW Mr. David Krol, Operations Supervisor 631-854-4158	**WEST BABYLON, NY**	30 MGD	996 panels	4' x 12'	SS	1993-1996	Plant
9	**Knollwood WWTP** Mr. Peter McGhee, Plant Superintendent 630-323-0677	**DUPAGE COUNTY, IL**	10 MGD Replacement	370 panels 315 panels	4' x 12' 4' x 12'	SS UltraFlex	1994 2012	Consoer, Townsend Chicago, IL

10 **Westside WWTP** Mr. Brandon Sherwood, Plant Superintendent 540-326-2078	**BLUEFIELD, VA**	5 MGD	202 panels	4' x 12'	SS	1995	Thompson & Litton Wise, VA
11 **Temecula Valley RWRF** Eastern Municipal Water District Mr. Mike Luker, Director of Water Reclamation 951-928-3777 951-296-5052	**RANCHO, CA**	8 MGD	228 panels	4' x 12'	SS	1996	Carollo Engineers Santa Ana, CA
12 **Scotts Valley WWTP** Mr. Scott Hamby, Division Manager 831-438-0732	**SCOTTS VALLEY, CA**	1.5 MGD	40 panels	4' x 12'	SS	1996	Kennedy/Jenks Consultants San Francisco, CA
13 **SEAFORD** Mr. Jeff Deats, Plant Superintendent 302-629-8340	**SEAFORD, DE**	2 MGD	60 panels	4' x 12'	PVC	1997	George, Miles & Buhr Salisbury, MD
14 **Padre Dam WWTP** Mr. Jeff Deats, Plant Superintendent 302-629-8340	**SANTEE, CA**			4' x 12'	SS	1997	
15 **NEW CASTLE, PA** Mr. Joseph Mcllvenny, Plant Manager 724-654-4664	**NEW CASTLE, PA**	10 MGD	216 panels	4' x 12'	PVC	1998	CTE Engineers Chicago, IL
16 **CONNERSVILLE, IN** Mr. Bill Ammerman, Plant Superintendent 765-825-9411	**CONNERSVILLE, IN**	6 MGD	120 panels	4' x 12'	SS	1998	M.D. Wessler & Associates Indianapolis, IN
17 **Chino Basin RP-1** Inland Empire Utilities Agency Mr. Patrick Shields, P.E., Operations Manager 909-947-4131 Mr. Gaspar Garza, Chief Operator 909-993-1893	**ONTARIO, CA**	45 MGD	852 panels	4' x 12'	SS	1998-1999	Cathcart Garcia von Langen Engineers, Irvine, CA
18 **Westminster WWTP** Mr. John Rawlings, Plant Superintendent Mr. Mark Milendeck, Chief Operator 410-848-4380	**WESTMINSTER, MD**	5 MGD	110 panels	4' x 12'	PVC	1999	Stearns & Wheler Bowie, MD

19 **ESCONDIDO, CA** Hale Avenue Resource Recovery Facility Mr. Darrell Hale, Plant Superintendent 760-839-6290	**ESCONDIDO, CA**	18 MGD	360 panels	4' x 12'	PVC	1999	Carollo Engineers San Diego, CA
Aeration Panel Replacement John Burcham (Superintendent) 760-839-6273 office, 760-535-6006 cell Jim Larzelere (Chief Operator) 760-839-4208		Replacement		4' x 12'	UltraFlex	2012	
20 **San Jacinto** Eastern Municipal Water District Mr. Jet Somsuvanskul, Plant Manager Mr. Brian Anderson, Chief Operator 909-654-2741	**HEMET, CA**	7.5 MGD	210 panels	4' x 12'	SS	1999	Carollo Engiineers Santa Ana, CA
21 **Moreno Valley, Plant 1** Eastern Municipal Water District Mr. Dean Mathes, Plant Manager 951-924-5487	**MORENO VALLEY, CA**	8 MGD	276 panels		PVC	1999	Carollo Engineers Santa Ana, CA
22 **CORONA, CA** Mr. Jonathan Daly, Operations Supervisor 909-736-2234	**CORONA, CA**	6.6 MGD	186 panels	4' x 12' 4' x 12'	PVC UltraFlex	1999 2012	Engineering Science Inc. Arcadia, CA
23 **West Hickman Creek WWTP** Mr. Tim Bullock, Plant Superintendent 859-272-1713	**LEXINGTON, KY**	12 MGD	368 panels		PVC	2000	PDR Engineers Lexington, KY
24 **Chino Basin RP-5** Inland Empire Utilities Agency Mr. Patrick Shields, P.E., Operations Manager 909-947-4131	**CHINO, CA**	20 MGD	400 panels	4' x 12'	PVC	2001	Carollo Engineers Santa Ana, CA
25 **Napa Valley WWTP Basin #2** Mr. Jeff Dutra, Operation & Maintenance Supervisor 707-258-6020	**NAPA VALLEY, CA**	4.3 MGD	110 panels	4' x 12'	PVC	2001	Carollo Engineers Walnut Creek, CA
26 **Glades County WWTP** Al Brown, Licenced Operator 863-227-0938	**GLADES COUNTY, FL**	0.18 MGD 0.18 MGD	7 panels 7 panels	4' x 12' 4' x 12'	PVC PVC	2002 2008	Craig A Smith & Associates Glades Dept. of Public Works
27 **Manteca – North & South Plants** Mr. Warren Shannon, WW Systems Superintendent Mr. Dane Jessee, WW Maintenance Supervisor 209-239-8433	**MANTECA, CA**	4.5 MGD	90 panels 90 panels 185 panels	4' x 12' 4' x 12' 4' x 12'	PVC PVC PVC	2002 2003 2005	Kennedy Jenks Palo Alto, CA

28 **YORKVILLE-BRISTOL, IL** Dan Eallonardo 847-878-2026	**YORKVILLE-BRISTOL, IL**	1.8 MGD	85 panels		PVC	2003	Walter E. Deuchler Associates Arlington Highs, IL
29 **SOCWA, Coastal TP** Ms. Hillary Kelly, Chief Operator 949-234-5487	**LAGUNA NIGUEL, CA**	6.7 MGD	94 panels		SS	2003	HDR Engineering Orange, CA
30 **Riddle Farms WWTP** Dominic Ross, Plant Superintendent 410-641-7134	**WORCESTER COUNTY, MD**	0.5 MGD	12 panels		PVC	2004	George, Miles and Buhr Salisbury, MD
31 **SOCWA, Joint Regional WWTP** Mr. Bob Waters, Chief Operator 949-234-5461	**LAGUNA NIGUEL, CA**	12 MGD	222 panels		PVC	2003	CGvL Engineers San Diego, CA
32 **White Slough WPCF** Mr. Gary Wiman, Plant Superintendent Mr. Del Kerlin, Assistant WWT Superintendent 209-333-6869	**LODI, CA**	6.6 MGD	96 panels	4' x 12'	PVC	2004	West Yost & Associates Eugene, OR & Davis, CA
33 **DELCORA Western Regional Treatment Plant** Mr. John Berry, Plant Superintendent 610-637-7054	**CHESTER, PA**	50 MGD	700 panels 20 panels	4' x 12' 4' x 12'	PVC UltraFlex	2005 2010	Weston Solutions West Chester, PA
34 **Moreno Valley RWRF, Plant 2** Mr. Dean Mathes, Plant Manager 951-924-5487	**MORENO VALLEY, CA**	8 MGD	216 panels	4' x 12'	PVC	2005	Carollo Engineers Santa Anna, CA
35 **Rodeo, CA** Steven S. Beall, P.E., Manager Jim Petalio, WWTP Operator 510-799-2970	**RODEO, CA**	1 MGD	29 panels	4' x 12'	PVC	2005	Rodeo Sanitary District
36 **Temecula Valley RWRF** Mrs. Melita Caldwell, Plant Manager Mr. Ed Westendorf, Plant Superintendent 951-296-5052	**TEMECULA, CA**	4.8 MGD	126 panels	4' x 12'	PVC	2005	Carollo Engineers Santa Anna, CA
37 **Meadowlark Water Reclamation Facility Expansion** Dawn McDougle 760-744-4550	**SAN DIEGO COUNTY, CA**	5 MGD	45 panels	4' x 12'	PVC	2006	Kennedy/Jenks Consultants San Diego, CA
38 **Millsboro WWTP Upgrade** Ken Niblett, Plant Superintendent 320-934-8171	**MILLSBORO, DE**	1.15 MGD	32 panels	4' x 11'	PVC	2006	Town of Millsboro

39 **White Slough WPCF** Phase 3 Improvements Mr. Gary Wiman, Plant Superintendent Mr. Del Kerlin, Assistant WWT Superintendent 209-333-6869	**LODI, CA**		192 panels	4' x 12'	PVC	2007	City of Lodi, CA Department of Public Works
40 **Napa Valley WWTP upgrade** Mr. Jeff Dutra, Operation & Maintenance Supervisor 707-258-6020, 707-312-1676	**NAPA VALLEY, CA**		128 panels 92 panels	4' x 9' 4' x 12'	PVC PVC	2008	City of Napa Valley, CA
41 **Coca Cola Las Margaritas**	**Las Margaritas, Mexico**	0.08 MGD	8 panels 2 panels	4' x 12' 4' x 6'	UltraFlex UltraFlex	2008 2008	Ecosistra
42 **Termo-eléctrica Tula** Sergio Rosas Chief of the Environmental Control Dept 011 52 (55) 54 90 40 00 ext 72 800 or 72 801	**Hidalgo, Mexico**	13.7 MGD	304 panels	4' x 12'	UltraFlex	2009	Thermoelectric Power Generation Coord. Power Generation Sub-Direction
43 **Woodridge WWTP** Aeration Tank Panel Replacement Bill Kennedy (Chief Operator) Jim Throw (Maintenance Supervisor) 630-985-7400	**DUPAGE COUNTY, IL**	11 MGD	128 panels 256 panels	4' x 10' 4' x 10'	UltraFlex UltraFlex	2009 2012	Dupage County
44 **George's Chicken WWTP** Bob Wolfe (Project Manager) 540-578-2843 Jeff Cappo (Lead Operator) 540-335-6530	**Edinburg, VA**	1.7 MGD	75 panels	4' x 12'	UltraFlex	2010	Reid Engineering
45 **Perris Valley RWRF Plant 3 Expansion** Mr. Kevin Shaw 951-928-3777	**PERRIS VALLEY, CA**	17 MGD	422 panels	4' x 12'	PVC	2011	City of Perris Valley
46 **Quincy Township** Mr. Ed Wilson (Chief Operator) 717-762-2612	**Quincy, PA**	0.3 MGD	10 panels	4' x 12'	UltraFlex	2011	Quincy Township
47 **City of O'Fallon**	**O'Fallon, MO**	11 MGD	36 panels	4' x 12'	UltraFlex	2011	HDR Inc. St. Louis, MO
48 **Termo-eléctrica Tula** Sergio Rosas Chief of the Environmental Control Dept 011 52 (55) 54 90 40 00 ext 72 800 or 72 801	**Hidalgo, Mexico**	13.7 MGD	176 panels	4' x 12'	UltraFlex	2011	Thermoelectric Power Generation Coord. Power Generation Sub-Direction

49	**Otay Water District, Ralph Chapman WRF Upgrade** Gene Palop (Reclamation Plant / SCADA Supervisor) 619-670-2271	**Spring Valley, CA**	1.3 MGD	39 panels	4' x 12'	UltraFlex	2011	MWH Global
50	**Mt. Vernon**	**Mt. Vernon, IN**		84 panels	4' x 12'	UltraFlex	2012	Bernardin, Lochmueller & Associates, Inc.

Technical Memorandum No. 2

Howard F. Curren Advanced Wastewater Treatment Plant

Diffused Air Reactor Diffuser Replacement Modeling Report

TECHNICAL MEMORANDUM

To: Charlie Lynch, P.E.
Rory Jones, E.I.

From: Emilie Moore, P.E.,Tetra Tech
Lauren Handell, P.E., Tetra Tech
Sean Scuras, P.E., PhD, BCEE, Tetra Tech

Re: Technical Memorandum No. 2 - Howard F. Curren Advanced Wastewater Treatment Plant Diffused Air Reactor Diffuser Replacement Modeling Report

Date: March 7, 2014

Tt #: 200-08494-12002

1.0 Introduction

The City of Tampa (City) operates the Howard F. Curren Advanced Wastewater Treatment Plant (HFCAWTP) which has a permitted capacity of 96 million gallons per day (MGD) on an average annual daily flow (AADF) basis. As Figure 1 presents, the basic liquid stream process includes preliminary treatment followed by primary sedimentation, two-stage activated sludge, denitrification filters, and disinfection. This memorandum focuses on the two-stage activated sludge system.

The first stage of the activated sludge system includes 6 high-rate activated sludge reactors that use high purity oxygen (HPO) for removal of carbonaceous biochemical oxygen demand (CBOD). These reactors are referred to as the HPO reactors throughout this memorandum. Each HPO reactor has four zones each with a mechanical aerator to mix the basin and facilitate oxygen transfer. The HPO reactors are followed by 12 rectangular clarifiers. High purity oxygen is generated on-site cryogenically using either a 60 ton per day (tpd) or an 80 tpd generating unit. The second stage of the activated sludge system uses 4 dissolved air reactors (DARs) which are mainly used for nitrification. Each DAR is divided into 6 zones each equipped with fine bubble membrane diffusers. Air is delivered to the diffusers by multi-stage centrifugal blowers. There is a spike line from the main pumping station (MPS) to the DARs that allows a portion of the combined primary effluent and plant recycle stream to bypass the HPO reactors.

The City has contracted with Tetra Tech to replace the diffusers in the DARs which have reached the end of their useful life. This memorandum summarizes the results of the process modeling performed to be incorporated into the design of the new DAR diffusers.

The current AADF at the HFCAWTP is 57 MGD which means the plant is operating at 59% of the rated capacity. While the facility is operated at lower flows and loadings than the design capacity, there is potential to modify operation by including the potential for denitrification to decrease operational costs for aeration and supplemental carbon feed to the denitrification filters.

Tetra Tech originally modeled denitrification performance and oxygen demand at the DARs based in part on 24 hour composite data provided by the City that indicated a significant quantity of nitrification at the

HPO reactors. Plant staff later indicated that the HPO effluent NOx-N concentrations are not as high or corresponding NH_3-N and TKN concentrations as low as reported by the daily composite lab data. This is supported by recent grab samples collected at the same location as the composite sampler and by Chemscan data from just downstream of the composite sample point. The results of the original Tetra Tech process modeling are included at the end of this memorandum. Based on those results, plant staff indicated a desire to install new diffusers and air flow control equipment that will allow one of the four DAR basins to be operated in a variety of modes to demonstrate the denitrification potential before converting the other DARs. In order to properly size the aeration equipment for the demonstration basin upgrade, the process model was recalibrated to better agree with the grab sample data that the HFCAWTP lab and operations staff now agree is the more reliable data to utilize.

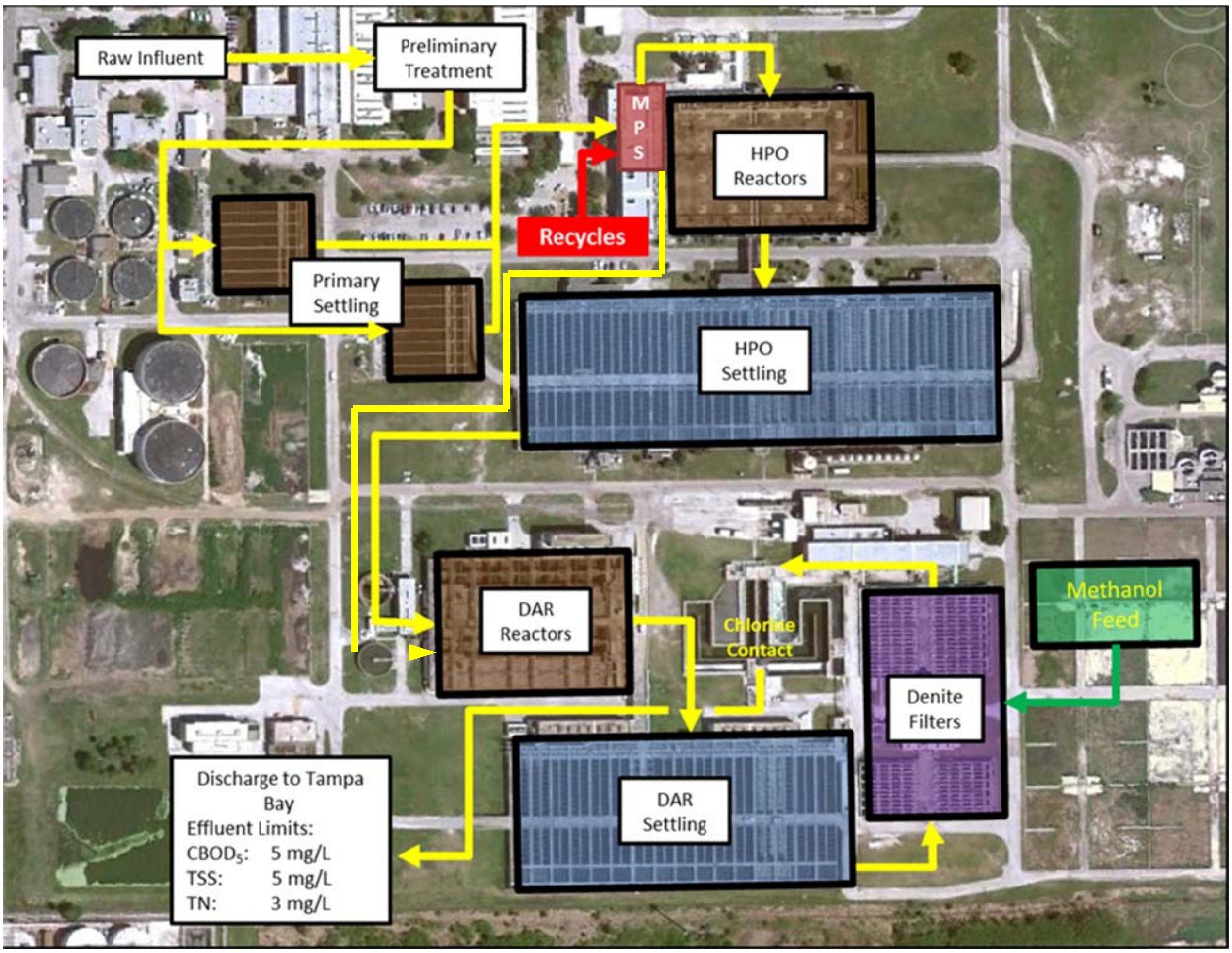


Figure 1
Overall Process Schematic of HFCAWTP

1.1 Project Goals

Diffuser system design requires estimates of the air demands at the DARs under various operating conditions. Denitrification has the potential to substantially reduce operational costs by reducing the energy required for aeration and by decreasing the methanol demand in the denitrification filters.

The City has established the following goals for the design of the diffuser replacement for the DARs:

1. The diffusers should use a tapered design to more closely match the oxygen demand profile through the reactors and to maximize oxygen transfer efficiency.
2. The diffuser design should be capable of providing sufficient aeration to meet the air demand at the DARs without any denitrification in the DARs.
3. The diffusers should not be negatively affected by periods of non-aeration so that anoxic conditions can be created to allow denitrification at the DARs.
4. DAR aeration system sizing should consider the full range of potential aeration demands for each zone: from 57 mgd with denitrification to 96 mgd without denitrification.
5. The effluent ammonia and TKN from the DARs should not exceed 0.8 and 2.0 mg/L, respectively.

To meet the City's goals, Tetra Tech used GPS-X® process modeling software developed by Hydromantis Environmental Software Solutions and originally configured to model the HFCAWTP two-stage activated sludge process by Greely and Hansen. Tetra Tech formulated and simulated several operational scenarios that vary the loading conditions and the degree of denitrification. The diffuser design will be based on the simulated oxygen demand in each zone from these scenarios.

2.0 Model Calibration

Wastewater process models, such as GPS-X, use bio-kinetic and stoichiometric parameters to model how microorganisms in the activated sludge process metabolize organic matter, nitrogen, and phosphorus throughout the process. The model used in this case focuses on carbon and nitrogen and does not include processes involving phosphorus. GPS-X uses over one hundred different bio-kinetic and stoichiometric parameters in the activated sludge model. Since it is not possible to verify each parameter independently, key parameters were calibrated to achieve good agreement between simulated performance and actual historical performance for three historic periods of stable operation. The HPO effluent NOx-N was calibrated to maintain less than 6 mg N/L throughout the dynamic calibration simulations for improved agreement with grab sampling and Chemscan results. The updated model calibration used the same calibration periods as were used in the earlier modeling. These periods are listed below and shown in Figures 2 and 3.

- Period 1: April 2009 through October 2009. This period was used to simulate stable HPO MCRT, low DAR MCRT, and variable flow and loading.
- Period 2: October 2009 through April 2010. This period was used to simulate stable HPO MCRT, variable DAR MCRT, and stable flow and load.
- Period 3: January 2012 through June 2012. This period was used to simulate stable HPO MCRT, High DAR MCRT, and stable flow and load.

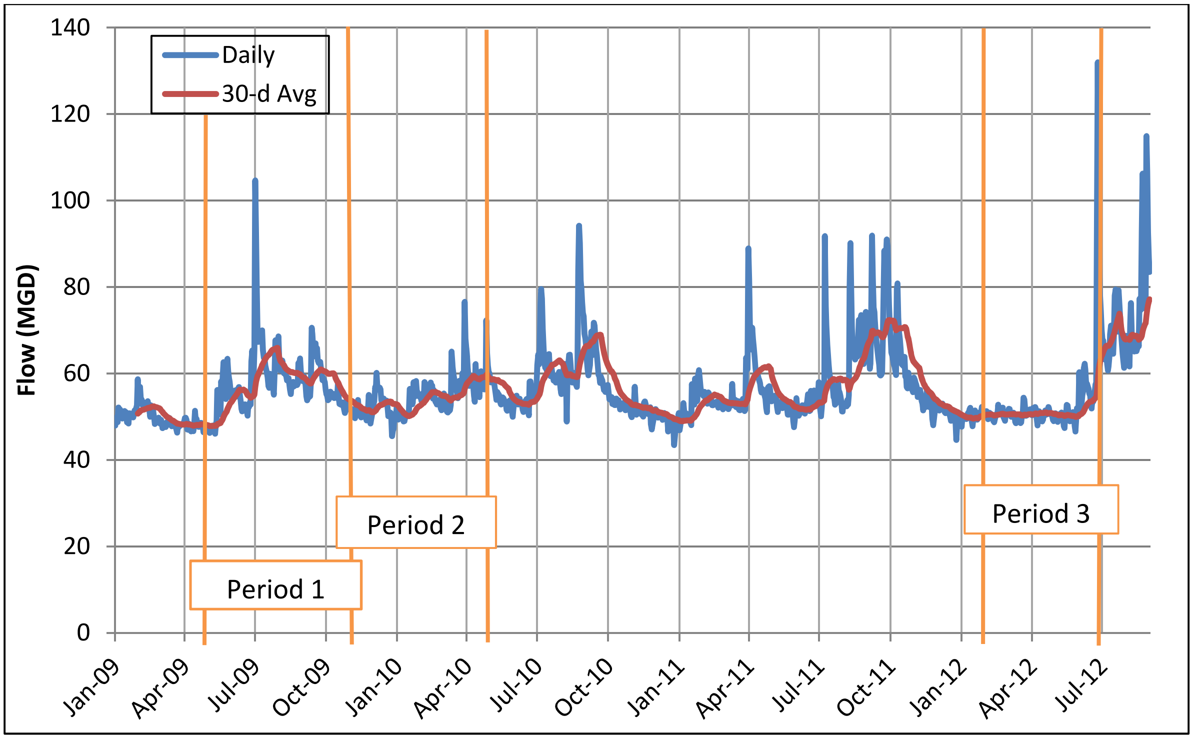


Figure 2
Historical Influent Flow at HFCAWTP from January 2009 through August 2012

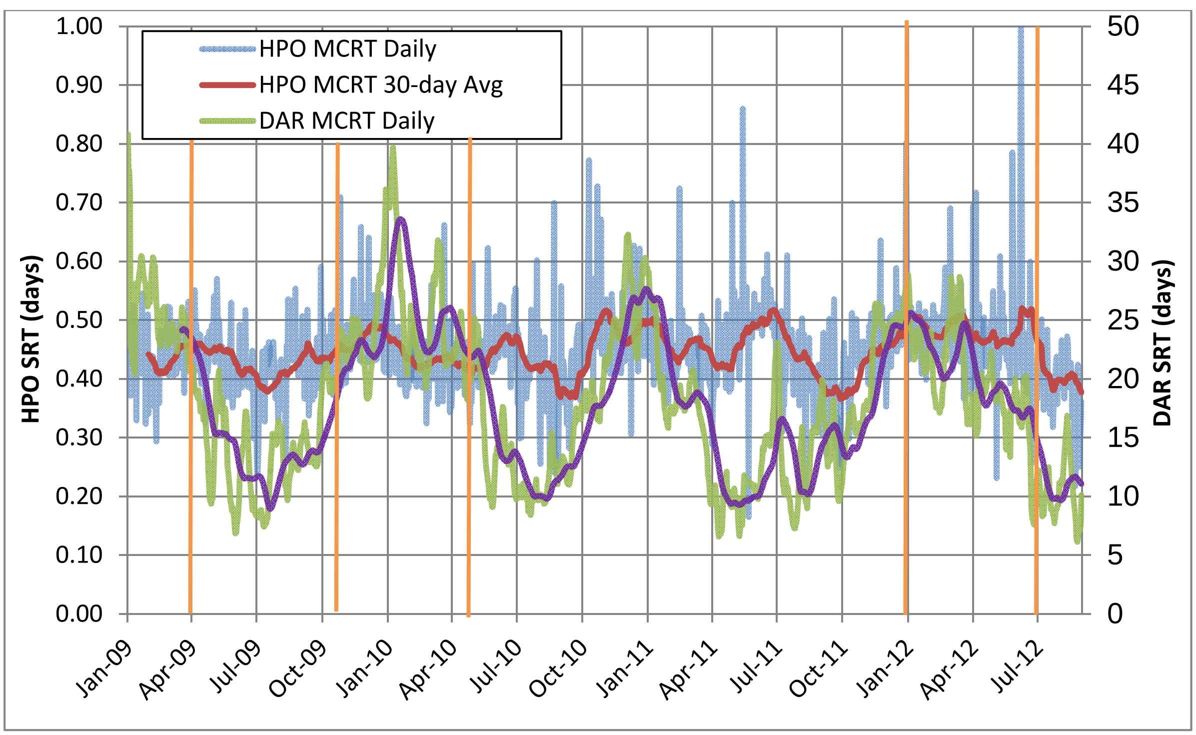


Figure 3
SRT for HPO and DAR from January 2009 through August 2012

The HFCAWTP monitors wastewater characteristics on a daily basis at the influent, primary effluent, HPO effluent, and DAR effluent. The actual historical daily composite combined primary effluent and recycles BOD, TSS and TKN concentration data as well as the calculated daily NH_3-N/TKN ratio were input into the GPS-X model for each calibration period. Since only raw influent flow data was available, an estimated 10 MGD of plant recycle flow was added to the raw influent flow for each day. In addition to the wastewater characterization data, the model used actual daily HPO and DAR RAS flow and SVI data. The historical daily MLSS concentration in the HPO reactors was entered into the model and used to control the wasting rate from the first-stage clarifiers. The calculated historical 30-day SRT for the DARs was input into the model and used by the model to set the nitrification stage wasting rate.

The effluent conditions and DAR MLSS predicted by the model were then compared to the actual conditions. The model's influent characterization (including fractionation), kinetic, stoichiometric, and settling parameters were modified to minimize the difference between (i.e. calibrate) the model's predicted effluent conditions to the actual effluent conditions to improve the accuracy of the simulations. As noted previously, HPO effluent daily composite data provided for the previous modeling has been determined to be an inaccurate representation of the nitrogen species in the HPO effluent. Therefore, influent fractions, kinetic, and stoichiometric parameters in the previous model were modified to bring the HPO effluent NOx-N to less than 6 mg N/L. The significant model parameters as calibrated for the modeling described in this report are shown in Tables 1 through 3.

Table 1
Influent (MPS Effluent) Ratios

Parameter	Value
particulate COD/VSS ratio	1.95
$BOD_5/BOD_{ultimate}$ ratio	0.75
soluble substrate/$BOD_{ultimate}$	0.43
ammonium/TKN ratio	0.73-0.74
part. org. N/total org. N ratio	0.9
VSS/TSS ratio	0.8

Table 2
Kinetic Parameters

Parameter	HPO Reactors	DARs
Active Heterotrophic Biomass		
heterotrophic maximum specific growth rate	3.7	3.2
readily biodegradable substrate half saturation coefficient	32	28
aerobic oxygen half saturation coefficient	0.2	0.2
anoxic oxygen half saturation coefficient	0.2	0.2
anoxic growth factor	1	0.8
nitrate half saturation coefficient	1	0.1
ammonia (as nutrient) half saturation coefficient	0.04	0.05
Active Autotrophic Biomass		
autotrophic maximum specific growth rate	0.65	0.7
ammonia (as substrate) half saturation coefficient	3	2
oxygen half saturation coefficient	0.5	0.3
autotrophic decay rate	0.17	0.17
Ammonification rate	0.016	0.08

Table 3
Stoichiometric Parameters

Parameter	HPO Reactors	DARs
heterotrophic yield	0.75	0.75
heterotrophic endogenous fraction	0.08	0.08
autotrophic yield	0.15	0.24
autotrophic endogenous fraction	0.08	0.08

A summary of the results for the modeling calibration is provided in Table 4 and

Table 5 for the HPO and DAR basins respectively. The summary tables compare the model's simulated effluent values for CBOD, TSS, and nitrogen species with the actual effluent values for the same period. The percentiles were included to demonstrate the degree to which the model was able to predict high and low values in addition to the average value. The actual HPO effluent concentrations for NOx-N, NH_3-N, and TKN are not shown, since the composite sample results were determined to be inaccurate.

Table 4
Summary of Modeling Calibration Results for HPO Reactor

Parameter		HPO Eff. BOD_5		HPO Eff. TSS		HPO Eff. TKN		HPO Eff. NH_3		HPO Eff. NOx	
		Model (mg/L)	Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)	Actual (mg/L)
Period 1	Average	29.2	25.0	13.7	9.0	23.3	N/A	17.6	N/A	3.6	N/A
	95th Percent	42.0	43.1	14.8	17.3	30.3	N/A	23.9	N/A	5.8	N/A
	90th Percent	38.6	37.1	14.6	13.6	29.0	N/A	22.6	N/A	5.2	N/A
	75th Percent	32.8	31.0	14.2	9.6	25.5	N/A	19.5	N/A	4.3	N/A
	25th Percent	24.1	18.0	13.3	6.4	20.9	N/A	15.5	N/A	2.8	N/A
	10th Percent	21.8	11.0	12.8	5.6	18.8	N/A	13.7	N/A	2.3	N/A
	5th Percent	20.1	7.0	12.7	4.8	17.5	N/A	13.2	N/A	2.0	N/A
Period 2	Average	20.7	32.0	11.4	8.9	25.6	N/A	19.4	N/A	3.7	N/A
	95th Percent	29.9	53.0	11.8	14.8	28.9	N/A	22.4	N/A	6.2	N/A
	90th Percent	26.6	49.4	11.7	13.2	28.2	N/A	21.8	N/A	5.5	N/A
	75th Percent	21.9	38.0	11.5	10.0	27.3	N/A	20.9	N/A	4.7	N/A
	25th Percent	17.5	24.0	11.2	6.8	24.0	N/A	18.0	N/A	2.6	N/A
	10th Percent	16.1	17.0	11.1	5.2	22.4	N/A	16.4	N/A	2.0	N/A
	5th Percent	15.2	15.0	11.1	4.8	21.3	N/A	15.7	N/A	1.6	N/A
Period 3	Average	27.5	32.6	11.3	7.9	28.1	N/A	22.1	N/A	3.5	N/A
	95th Percent	47.2	57.0	11.7	15.2	32.9	N/A	27.1	N/A	6.1	N/A
	90th Percent	41.6	49.0	11.5	12.8	32.3	N/A	26.3	N/A	5.6	N/A
	75th Percent	33.2	40.0	11.4	8.8	31.2	N/A	24.9	N/A	4.6	N/A
	25th Percent	19.8	24.0	11.2	5.2	25.7	N/A	19.6	N/A	2.4	N/A
	10th Percent	17.3	17.1	11.1	4.0	21.2	N/A	16.1	N/A	1.6	N/A
	5th Percent	16.0	13.0	10.9	3.6	19.6	N/A	14.4	N/A	1.3	N/A

Table 5
Summary of Modeling Calibration Results for DAR Reactor

Period	Parameter	DAR Eff. BOD_5 Model (mg/L)	DAR Eff. BOD_5 Actual (mg/L)	DAR Eff. TSS Model (mg/L)	DAR Eff. TSS Actual (mg/L)	DAR Eff. TKN Model (mg/L)	DAR Eff. TKN Actual (mg/L)	DAR Eff. NH_3 Model (mg/L)	DAR Eff. NH_3 Actual (mg/L)	DAR Eff. NOx Model (mg/L)	DAR Eff. NOx Actual (mg/L)
Period 1	Average	4.3	N/A	6.1	7.3	1.04	1.33	0.12	< 0.24	24.4	24.2
	95th Percent	4.7	N/A	6.7	11.3	1.12	1.63	0.15	0.24	31.4	30.2
	90th Percent	4.6	N/A	6.6	9.6	1.11	1.58	0.14	0.24	30.2	29.3
	75th Percent	4.4	N/A	6.3	8.0	1.07	1.49	0.13	0.24	27.2	26.0
	25th Percent	4.1	N/A	5.9	6.2	1.00	1.16	0.11	0.24	21.4	21.9
	10th Percent	4.0	N/A	5.7	4.9	0.98	1.01	0.10	0.24	18.6	19.9
	5th Percent	3.9	N/A	5.5	4.4	0.96	0.98	0.10	0.24	17.1	18.3
Period 2	Average	4.5	N/A	4.9	6.3	1.03	1.22	0.12	0.24	27.3	25.8
	95th Percent	5.2	N/A	5.7	9.0	1.17	1.52	0.15	0.24	31.0	29.7
	90th Percent	5.1	N/A	5.6	8.6	1.14	1.45	0.14	0.24	30.3	28.7
	75th Percent	5.0	N/A	5.3	7.6	1.11	1.34	0.13	0.24	28.8	27.6
	25th Percent	4.0	N/A	4.5	5.2	0.92	1.10	0.11	0.24	25.8	24.1
	10th Percent	3.8	N/A	4.4	3.6	0.88	1.02	0.10	0.24	24.5	22.7
	5th Percent	3.7	N/A	4.3	3.0	0.86	0.96	0.10	0.24	23.8	22.3
Period 3	Average	4.7	N/A	6.5	8.3	1.11	1.28	0.12	0.24	29.3	28.1
	95th Percent	5.8	N/A	7.2	12.2	1.25	1.65	0.18	0.24	33.4	32.6
	90th Percent	5.6	N/A	7.0	10.6	1.24	1.55	0.15	0.24	32.8	31.9
	75th Percent	5.2	N/A	6.7	9.6	1.18	1.40	0.13	0.24	31.6	30.4
	25th Percent	4.2	N/A	6.1	6.6	1.03	1.13	0.10	0.24	28.2	26.8
	10th Percent	4.0	N/A	5.9	5.4	1.00	1.01	0.09	0.24	25.5	24.5
	5th Percent	3.9	N/A	5.7	4.8	0.98	0.97	0.09	0.24	20.3	21.6

The modeling calibration was able to achieve a reasonable degree of agreement between simulated and actual performance over the three calibration periods. Additional details on the calibration simulations can be found at the end of this memorandum. In addition to these printed details, the complete modeling reports are provided electronically on a CD. Each complete modeling report includes model inputs and detailed output.

3.0 Denitrification and Air Demand Modeling

The recalibrated GPS-X model was used to model the denitrification and nitrification in the DARs with the HPO reactors operating similarly to current operation. The concentrations corresponding to the annual average and worst case month loading conditions modeled are shown in Table 6 below. The worst case month condition is based on the historical monthly average conditions corresponding to the worst performance. This occurs when temperatures are the lowest with a high TKN load. The minimum monthly average temperature of 70 F was used for the worst case modeling. Both loading conditions are assumed to be at annual average daily flow.

Table 6
Combined Primary Effluent and Recycles Concentrations at Annual Average and Worst Case Month Loading Conditions

Loading Condition	BOD (mg/L)	TSS (mg/L)	TKN (mg/L)	NH_3-N/TKN
Annual Average (AA)	125	83	36.5	0.73
Worst Case Month	161	90	43.6	0.74

DARs were assumed to be operated either fully aerobic to achieve maximum nitrification or with zones 1 and 2 anoxic to achieve a degree of denitrification. No internal recycle was used in the simulations as results indicated that excess nitrate was present in the zone 2 effluent. One of the most important operational parameters affecting the amount of denitrification achieved in the DAR is the amount of carbon added via the spike line. More carbon (via more spike flow) to the DARs will increase the amount of denitrification. However, adding more spike flow will increase the heterotrophic biomass which will decrease the autotrophic biomass available for nitrification given the same MLSS concentration. Consequently, increasing denitrification by adding spike flow limits the DARs nitrification capacity. The SRT and percentage of the flow bypassing the HPOs (spike %) were balanced and optimized to achieve the most denitrification while keeping the DAR effluent NH3-N below 0.8 mgN/L and the MLSS at approximately 3500 mg/L or less.

The following assumptions and limits regarding other operational parameters were also applied when performing the modeling:

- 17.5% of the plant influent flow was added to the plant influent flow to account for plant recycle that is returned to or upstream of the MPS since daily recycle flow data was not available.
- Since entering the reported HP of the aerators resulted in unreasonably high modeled DO values and there was not enough information to model or calibrate the HPO system, the DO in the HPO reactors was set as follows:
    - Zone 1 = 12 mgO_2/L
    - Zone 2 = 12 mgO_2/L
    - Zone 3 = 10 mgO_2/L
    - Zone 4 = 3 mgO_2/L
- Maximum HPO MLSS = 2500 mg/L
- Maximum DAR MLSS = 3500 mg/L It was assumed that a greater MLSS concentration could result in exceeding the maximum solids loading rate of the DAR clarifiers.
- The DO in all aerated zones of the DARs was maintained at 2.0 mg/L.

3.1 Steady-State Modeling

The purpose of the steady-state modeling was to determine at what flow it was no longer beneficial to run DAR zones 1 and 2 as anoxic zones under worst case conditions based on whether necessary nitrification was being achieved, the amount of denitrification occurring in the DARs, and the increase in air demand in each zone. The steady state modeling also provided information regarding the DAR oxygen demands at each flow rate, which was used by the City to determine the Case to be used as the basis for design of the upgraded aeration system in each zone. Steady-state modeling Cases were simulated at flow rates from 57 MGD (the current AADF) to 96 MGD (the rated plant capacity) on a raw influent AADF basis in increments of 5 MGD. Initially two HPO reactors and four DARs were online. As flows increased, additional HPO reactors were put online. All steady state modeling was performed assuming worst case month loading conditions. Because the diffuser system upgrades are to be implemented in phases, the simulations at 57 and 62 mgd (Cases 1 and 2) were performed assuming only DAR1 (the demonstration basin) is modified and operated in denitrification mode. Simulations for Cases 3 – 9 were performed assuming all DARs modified and operated in denitrification mode. Case 10 simulates all DARs operating fully aerated to achieve maximum nitrification. Table 7 shows the flow and simulation type for each model case.

Table 7
Steady-state Simulation Cases

Case	Plant Influent	Flow w/Recycles	Simulation
1	AADF = 57	67 MGD	Demo period, DAR 1 Zones 1 and 2 Anoxic
2	AADF = 62	72.85 MGD	Demo period, DAR 1 Zones 1 and 2 Anoxic
3	AADF = 67	78.73 MGD	Fully modified, All DARs Zone 1 and 2 Anoxic
4	AADF = 72	84.6 MGD	Fully modified, All DARs Zone 1 and 2 Anoxic
5	AADF = 77	90.48 MGD	Fully modified, All DARs Zone 1 and 2 Anoxic
6	AADF = 82	96.35 MGD	Fully modified, All DARs Zone 1 and 2 Anoxic
7	AADF = 87	102.23 MGD	Fully modified, All DARs Zone 1 and 2 Anoxic
8	AADF = 92	108.1 MGD	Fully modified, All DARs Zone 1 and 2 Anoxic
9	AADF = 96	112.8 MGD	Fully modified, All DARs Zone 1 and 2 Anoxic
10	AADF = 96	112.8 MGD	All Zones Aerated

3.1.1 Modeling Results

The simulated water quality characteristics for each steady state modeling case are summarized in Table 88 and Table 9 for the HPO reactors and the DARs respectively. Note that for Cases 1 and 2 only DAR 1 is operating in denitrification mode so the nitrate (NOx-N) leaving DAR 1 is reported separately because the blended nitrate level for the overall DAR effluent includes the effluent from the three fully aerated basins making the DAR 1 effluent NOx-N a better indicator of the denitrification performance of the basin configuration. Beginning with Case 3, the effluent nitrate in Table 9 is the result of simulated denitrification in all four DARs.

Table 8
Steady-state Modeling Results Summary HPO Reactors

Case	Basins Online	SRT (days)	Avg. MLSS (mg/L)	Avg. cBOD5 (mg/L)	Avg. TSS (mg/L)	Avg. NOX (mg-N/L)	Avg. NH3 (mg-N/L)
1	2	0.61	1800	23.59	12.03	5.29	21.57
2	3	0.85	1800	17.46	12.41	7.79	19.36
3	3	0.77	1800	19.42	11.84	5.19	21.83
4	3	0.70	1800	21.63	12.27	4.33	22.59
5	4	0.73	1500	21.39	12.63	4.04	22.89
6	4	0.82	1800	19.72	13.17	4.15	22.91
7	4	0.76	1800	21.8	13.77	3.1	23.88
8	5	0.77	1550	22.12	14.21	2.58	24.43
9	5	0.75	1600	23.12	14.73	1.99	25.02
10	6	1.01	1800	17.47	12.48	0.61	27.05

Table 9
Steady-state Modeling Results Summary DARs

Case	SRT	MLSS	Spike %	Eff NOx-N	Eff TKN	Eff NH_3-N	DAR1 Eff NOx-N	DAR1 Eff NH_3-N	Eff BOD	Eff TSS
1	14	3494	26	29.7	1.87	0.33	25.65	0.68	8.31	12.05
2	13.5	3510	26	30.14	1.91	0.34	26.55	0.74	8.47	12.42
3	14.5	3485	20	26.12	2.38	0.73	-	-	8.9	12.7
4	14	3496	17.5	26.12	2.45	0.76	-	-	9.24	13.10
5	13.8	3496	17.5	26.47	2.51	0.78	-	-	9.47	13.48
6	13.75	3508	14	27.04	2.56	0.79	-	-	9.64	13.93
7	13.7	3499	11	27.14	2.59	0.79	-	-	9.9	14.31
8	13.7	3499	9	27.41	2.63	0.79	-	-	10.10	14.72
9	13.7	3505	7	27.56	2.66	0.78	-	-	10.3	15.08
10	15	2790	3	31.74	1.84	0.13	-	-	9.1	13.48

The actual oxygen required (AOR) in each zone of the DARs is reported in Table 10. This is the quantity of oxygen that is needed by the biomass based on carbon and nitrogen loadings. It changes with flow, spike load, and extent of denitrification. Only Case 10 includes aeration in zones 1 and 2 to simulate the maximum extent of nitrification that can be achieved at the rated capacity of 96 mgd and the oxygen demand associated with it. Note that although the total Case 10 oxygen demand exceeds that for all but Case 9, the oxygen demand in zones 3 – 6 is greater in all of the denitrification simulations (Cases 1-9). Based on the results summarized in Table 10, City staff determined that the design for the demonstration project diffuser system should be based on the flows represented by Case 10 (96 mgd nitrification only) and Case 3 or 4 (67 and 72 mgd with denitrification). The average annual daily influent flow is not expected to exceed 72 MGD (Case 4) during the life of the diffusers. Diffusers in zones 3 through 6 will be designed to accommodate an AADF of 67 or 72 MGD with zones 1 and 2 operated as anoxic zones. Diffusers in Zones 1 and 2 will be designed for the 96 mgd flow associated with Case 10. Actual design requirements for Cases 3 and 4 will be based on dynamic modeling to simulate diurnal variations in loading and oxygen demand.

Table 10
Steady State DAR Oxygen Demand by Zone

Case	Total AOR	AOR by Zone, lbs/day					
	lbs/day	1	2	3	4	5	6
1*	94,152	0	0	7603	6346	4554	2505
2*	95,216	0	0	7643	6373	4657	2637
3	94,361	0	0	8486	7103	5174	2826
4	101,832	0	0	9114	7650	5622	3073
5	107,656	0	0	9620	8070	5961	3263
6	113,090	0	0	10112	8479	6268	3414
7	121,275	0	0	10869	9119	6726	3605
8	128,213	0	0	11511	9658	7114	3770
9	134,850	0	0	12137	10183	7480	3913
10	132,961	12091	10602	7344	3458	1621	1147

*AOR by zone shown for converted DAR1 only, AOR for other DARS is greater

3.2 Diurnal Modeling

Diurnal modeling was performed to determine the minimum and maximum daily oxygen demands. These are useful for sizing the diffuser system, aeration piping and valves, and blower operating range. Diurnal factors applicable to flow, BOD/TSS, and TKN originally prepared for the City by Greely and Hansen were adopted for this study. The flow factors and concentration factors were used to calculate load factors, which were normalized to 1.00 over the 24 hour cycle. The normalized load factors were then divided by the flow factors to obtain the concentration factors entered into the model and shown in Figure 4 below.

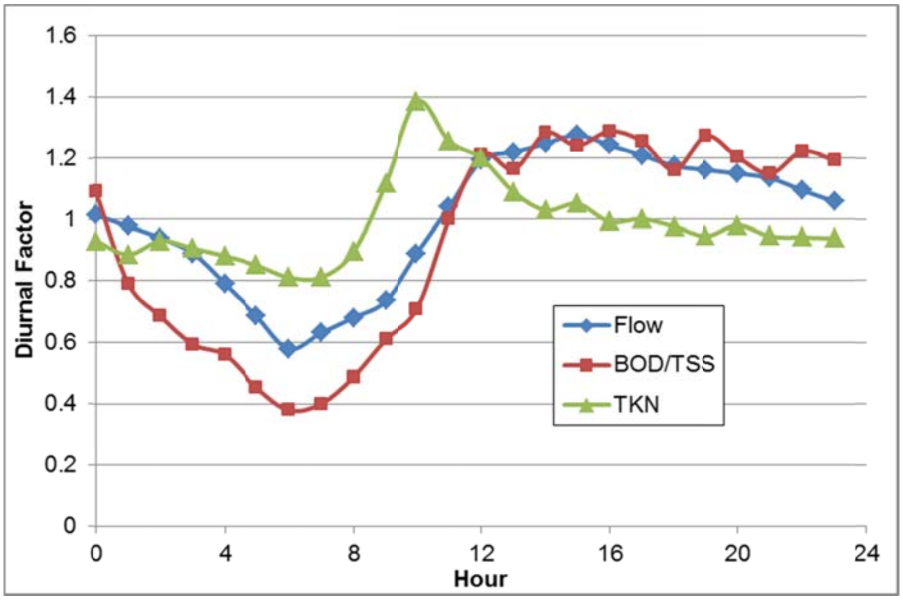


Figure 4
Diurnal Factors Hourly Variation

As shown in Table 11, the diurnal simulations were performed for three flow rates (57, 67, and 72 mgd) and two loading conditions (annual average: AA and worst case month). The flow rates correspond to the current flow (57 mgd) and the Case 3 and Case 4 flows (67 and 72 mgd respectively) selected for denitrification design by the City. The 57 mgd cases also assume that only one of the four DARs is operated with denitrification (the demonstration phase). The AA conditions were modeled at the warmest water temperature when oxygen transfer will be least efficient. The worst case conditions were modeled at the coldest water temperature when biological process rates will be lowest and longer SRTs will be required. Diurnal conditions were not simulated for the 96 mgd flow rate of Case 10 because it is not expected to occur during the life of the diffuser system.

Table 11
Diurnal Modeling Cases and Conditions

Case	Plant Influent, MGD	Flow w Recycles, MGD	Loading Condition	Temperature
A (demo)	57	67	AA	86.4 F
B	67	78.73	AA	86.4 F
C	72	84.6	AA	86.4 F
D (demo)	57	67	Worst Case	70 F
E	67	78.73	Worst Case	70 F
F	72	84.6	Worst Case	70 F

3.2.1 Modeling Results

The simulated water quality characteristics for each diurnal modeling case are summarized in Table **8**12 and Table 13 for the HPO reactors and the DARs respectively. The concentrations reported are the average of the hourly concentrations predicted by each simulation. Note that for Cases E and F the effluent ammonia-N and TKN at the DARs cannot be maintained within the desired limits (< 0.8 mg/L NH_3-N and < 2.0 mg/L TKN). A revised version of Case E (Case E1) was developed by increasing the SRT to provide the additional nitrification desired. The spike flow for Case E1 is also less than that for Case E to avoid excessive increase in the MLSS. Case F is beyond the denitrifying capacity of the system while complying with the established treatment parameters.

Table 12
Diurnal Modeling Results Summary HPO Reactors 24 hour Average

Case	Basins Online	SRT (days)	Avg. MLSS (mg/L)	Avg. $cBOD_5$ (mg/L)	Avg. TSS (mg/L)	Avg. NO_X (mg-N/L)	Avg. NH_3 (mg-N/L)
A (demo)	2	0.44	1200	30.4	11.9	4.95	17.32
B	3	0.56	1200	23.87	12.74	5.69	16.13
C	3	0.53	1200	26.07	13.13	5.14	16.77
D (demo)	2	0.61	1800	28.74	12.09	5.2	28.22
E	3	0.77	1800	21.88	11.9	5.25	21.65
E1	3	0.79	1900	23.33	12.44	2.44	25.25
F	3	0.75	1900	23.11	12.37	4.7	22.89

Table 13
Diurnal Modeling Results Summary DARs 24 Hr Average

Case	Spike %	SRT (days)	Avg. MLSS (mg/L)	Avg. NO_X (mg-N/L)	Avg. NH_3 (mg-N/L)	Avg. TKN (mg-N/L)	Avg. TSS (mg/L)	Avg. $cBOD_5$ (mg/L)
A (demo)	27	10	2750	23.70	0.19	1.41	10.26	5.77
B	25	10	2963	19.55	0.33	1.67	11.5	6.28
C	25	10	3257	19.3	0.33	1.77	12.6	6.72
D (demo)	26	13.3	3498	29.1	0.49	2.05	12.13	8.6
E	20	14.2	3487	24.88	1.39	3.05	12.78	9.11
E1	10	20	3554	26.47	0.76	2.43	12.97	8.37
F	17.5	14	3564	25.25	1.14	2.86	13.35	9.37

Since the diurnal results showed it is difficult to achieve the required nitrification with Zones 1 and 2 operating as anoxic above 67 MGD (Case F) under worst case conditions, the 67 MGD cases (cases B and E1) were established as the design basis for providing year round denitrification in the DARs.

The actual oxygen required (AOR) in each zone of the DARs under diurnal loadings is reported in Table 14. This is the quantity of oxygen that is needed by the biomass based on hourly carbon and nitrogen loadings. It changes with flow, spike load, and extent of denitrification. Note that the total AOR is the combined air demand for all four basins. The highlighted rows in Table 14 show the design oxygen demands for zones 3 through 6. The minimum AOR is for the demonstration phase at 57 mgd. The average AOR is for the 67 mgd case at annual average conditions. The maximum AOR for zones 3-6 is based on Case E1 for 67 mgd under worst case month conditions.

Table 14
Diurnal DAR Oxygen Demand by Zone

Case		Total AOR lbs/day	AOR by Zone, lbs/day					
			1	2	3	4	5	6
A (demo)	Average	80,773	N/A	N/A	7,909	5,243	2,921	1,678
	Min	54,499	N/A	N/A	6,691	2,769	1,379	1,183
	Max	102,442	N/A	N/A	8,605	6,919	4,782	2,521
B	Average	79,533	N/A	N/A	8,749	5,873	3,352	1,910
	Min	52,982	N/A	N/A	7,399	3,084	1,501	1,259
	Max	103,669	N/A	N/A	9,555	7,766	5,587	3,050
C	Average	87,445	N/A	N/A	9,611	6,453	3,685	2,112
	Min	58,332	N/A	N/A	8,137	3,376	1,662	1,406
	Max	114,384	N/A	N/A	10,490	8,566	6,197	3,389
D (demo)	Average	95,749	N/A	N/A	7,525	6,077	4,426	2,917
	Min	64,379	N/A	N/A	6,824	4,221	2,001	1,428
	Max	121,639	N/A	N/A	7,960	6,979	6,203	4,897
E	Average	93,068	N/A	N/A	8,255	6,712	4,969	3,319
	Min	63,252	N/A	N/A	7,535	4,695	2,111	1,417
	Max	115,494	N/A	N/A	8,700	7,658	6,893	5,623
E1	Average	96,906	N/A	N/A	9,382	7,272	4,808	2,771
	Min	63,683	N/A	N/A	8,527	4,452	1,714	1,237
	Max	126,398	N/A	N/A	9,877	8,721	7,596	5,410
F	Average	100,722	N/A	N/A	9,101	7,354	5,315	3,419
	Min	68,154	N/A	N/A	8,322	5,031	2,186	1,494
	Max	127,083	N/A	N/A	9,586	8,482	7,643	6,076

4.0 Recommendation on Basis of Design for Aeration Upgrade

Table 15 shows the recommended oxygen demands for use in the diffused aeration system design. In order to ensure that the current rated capacity of the plant is maintained, diffusers should be installed in zones 1 and 2 to meet the maximum AOR shown below. These numbers are based on the steady state 96 MGD case (Case 10) at worst case month conditions with all DAR zones fully aerated. The maximum design oxygen demands for zones 3 through 6 are based on zones 1 and 2 being operated as anoxic at 67 MGD AADF under the worst case conditions (Case E1). At higher flows it may be necessary to aerate either one or two of the first two DAR zones under high loadings and cooler temperatures. The minimum oxygen demand case is based on the current flow, with average loading and high temperatures and only DAR 1 in denitrification mode (Case A). The average oxygen demand is based on annual average loading conditions at 67 MGD and warm water temperatures. The total AOR is taken from the diurnal modeling for the minimum and average cases (Case A and Case B respectively) and from the steady state modeling for Case 10 (96 mgd) for the maximum case because although it did not show the greatest oxygen demand for zones 3-6, it did exhibit the greatest overall oxygen demand (all zones) of any simulation case because it includes aeration of zones 1 and 2 as well as all of the other zones.

Table 15
Air Demands Recommended for Basis of Design

Design Basis	Total AOR lbs/day	AOR by Zone, lbs/day 1	2	3	4	5	6
Minimum	54,499	0	0	6,691	2,769	1,379	1,183
Average	79,533	0	0	8,749	5,873	3,352	1,910
Maximum	132,961*	12,091	10,602	9,877	8,721	7,596	5,410

*The maximum total AOR is based on the Case 10 steady–state simulation. It is not the sum of the maximum AOR in each zone because the maximum AOR in zones 1 and 2 is based on Case 10 and the maximum AOR in zones 3-6 is based on Case E1.

END OF MEMORANDUM

Attachment

Howard F. Curren Advanced Wastewater Treatment Plant

Initial Modeling Results

DRAFT MEMORANDUM

To: Charlie Lynch, P.E.
Rory Jones, E.I.

From: Emilie Moore, P.E., Tetra Tech
Steve Tamburini, P.E., Tetra Tech
Sean Scuras, P.E., PhD, BCEE, Tetra Tech
John Toomey, P.E., Tetra Tech

Re: Howard F. Curren Advanced Wastewater Treatment Plant Diffused Air Reactor Diffuser Replacement Modeling Report

Date: July 22, 2013

Tt #: 200-08494-12002

1.0 Introduction

The City of Tampa (City) operates the Howard F. Curren Advanced Wastewater Treatment Plant (HFCAWTP) which has a permitted capacity of 96 million gallons per day (MGD) on an average annual daily flow (AADF) basis. Figure 1 presents the overall process schematic for the treatment facility which in general includes preliminary treatment followed by primary sedimentation, two-stage activated sludge, denitrification filters, disinfection, solids digestion, and biosolids dewatering. This memorandum focuses on the two-stage activated sludge system.

The first stage of the activated sludge system includes 6 high-rate activated sludge reactors that use high purity oxygen (HPO) for removal of carbonaceous biochemical oxygen demand (CBOD). These reactors are referred to as the HPO reactors throughout this memorandum. Each HPO reactor has four zones, each with a mechanical aerator to mix the basin and facilitate oxygen transfer. The HPO reactors are followed by 12 rectangular clarifiers. High purity oxygen is generated on-site cryogenically using either a 60 ton per day (tpd) or an 80 tpd generating unit. The second stage of the activated sludge uses 4 dissolved air reactors (DARs) which are mainly used for nitrification. Each DAR is divided into 6 zones, each equipped with fine bubble membrane diffusers. Air is delivered to the diffusers by multi-stage centrifugal blowers. There is a spike line from the main pumping station (MPS) to the DARs that allows for a portion of the primary effluent to bypass the HPO reactors. The City has contracted with Tetra Tech to replace the DAR basins diffusers which have reached the end of their useful life. This memorandum summarizes the results of the process modeling performed to consider alternatives for design of the new DAR diffusers.

The current AADF at the HFCAWTP is approximately 56 MGD which means the plant is operating at about 59% of the rated capacity. While the facility is operated at lower flows and loadings than the design capacity, there is potential to optimize the operation to minimize operations costs.

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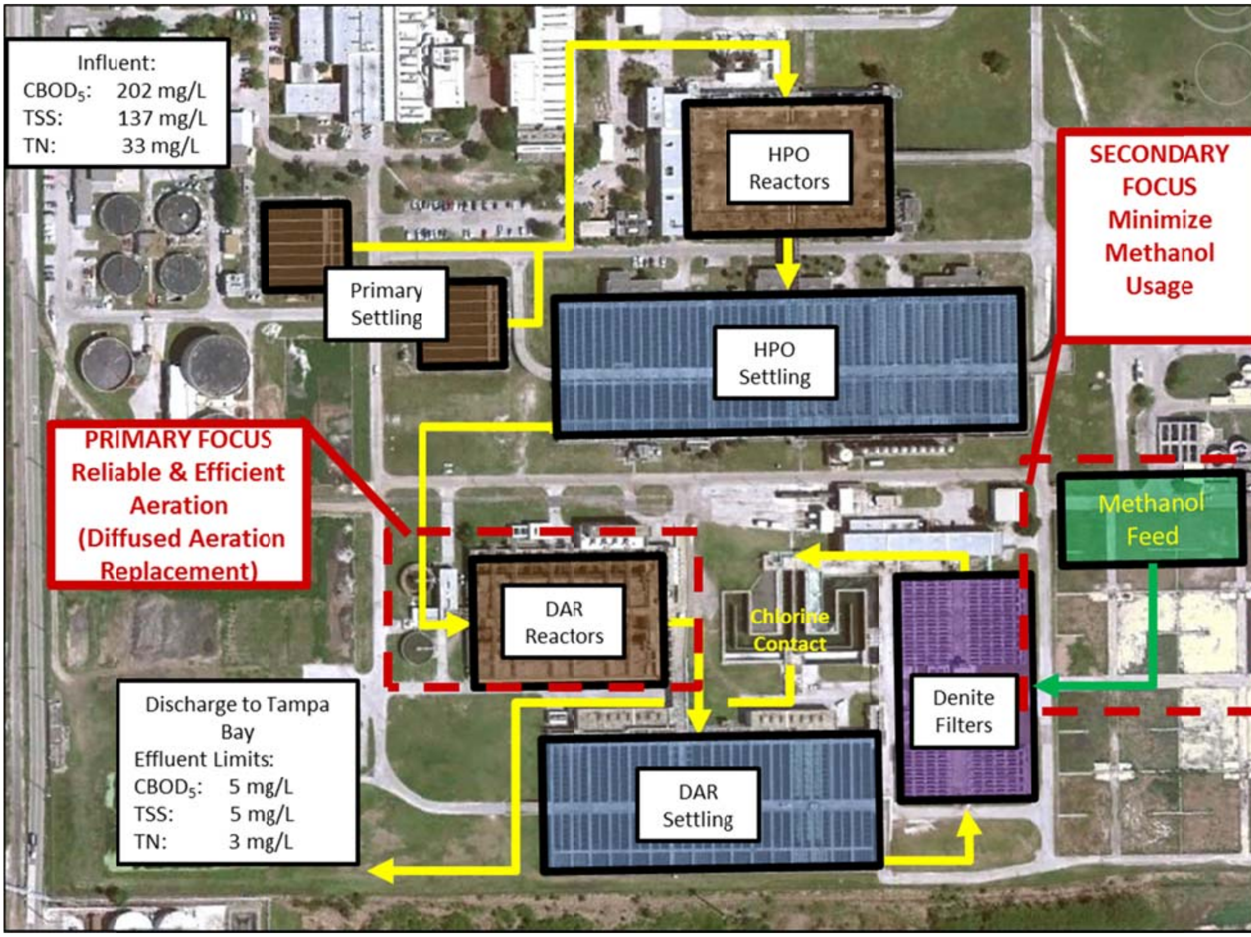

Figure 1
Overall Process Schematic of HFCAWTP

1.1 Project Goals

Diffuser system design requires estimates of the air demands at the DARs which in turn requires estimates of the oxygen demand met at the HPO reactors and by denitrification. Denitrification has the potential to substantially reduce operational costs by reducing the energy required for aeration and by decreasing the methanol demand in the denitrification filters.

The City has established the following goals for the design of the diffuser replacement for the DARs:

1. The diffusers should use a tapered design to more closely match the oxygen demand profile through the reactors and to maximize oxygen transfer efficiency.
2. The diffuser design should be capable of providing sufficient aeration to meet the air demand at the DARs without any denitrification in the DARs and without any nitrification in the HPO basins.
3. The diffusers should not be negatively affected by periods of non-aeration so that anoxic conditions can be created to allow denitrification at the DARs.
4. The DAR diffuser system is to maintain efficient operation in the event operational changes are made at the HPO reactors.
5. The effluent ammonia and TKN from the DARs should not exceed 0.8 and 2.0 mg/L respectively.

To meet the City's goals, Tetra Tech used GPS-X® process modeling software developed by Hydromantis Environmental Software Solutions to model the two-stage activated sludge process. Tetra Tech formulated and modeled different operational scenarios that vary the oxygen demand distribution and the degree of denitrification. The diffuser design will be based on information from all of these scenarios to provide the flexibility necessary to maintain efficient operation over a range of operational strategies. The modeled operational scenarios included:

- Alternative 1: Base-line Conditions – The first scenario is operating both the DAR and HPO reactors using the current operational approach currently used. This relies on CBOD removal in the HPO reactors, nitrification in the DARs, and denitrification in the denitrification filters.
- Alternative 2: HPO Operation with Denitrification in DARs – The second scenario includes using the current operation in the HPO reactors while operating the DARs to achieve some denitrification.
- Alternative 3: HPO Conversion to CAS with Denitrification in the DARs – The third scenario involves converting the HPO reactors to conventional air activated sludge (CAS) with denitrification in the DARs.
- Alternative 3A: HPO Conversion to CAS with Denitrification in the CAS reactors and the DARs – This scenario involves a modification to the operational parameters assumed for the CAS reactors which allows for denitrification in the CAS and in the DARs.

2.0 Model Calibration

Wastewater process models, such as GPS-X, use bio-kinetic and stoichiometric parameters to model how microorganisms in the activated sludge process metabolize organic matter, nitrogen, and phosphorus throughout the process. GPS-X uses over one hundred different bio-kinetic and stoichiometric parameters in the activated sludge model. Although each of these parameters does not need to be individually verified, and default values can be used for most parameters, the composition of wastewater has enough variation to require models to be calibrated. Calibration of the model can be verified by simulating historic periods of stable operation to determine if the model accurately predicted actual conditions.

The City provided Tetra Tech with a GPS-X model originally prepared by Greeley and Hansen (G&H) in 2012. Using historical influent and process control data from January 2009 through August 2012, Tetra Tech identified three periods of time when the operation appeared to be most stable with respect to influent flow, load, and MCRT within the HPO and DAR systems. The stable periods that are best suited for model calibration checks and refinements are shown in Figures 2 and 3 and are more specifically described as follows:

- Period 1: April 2009 through October 2009. This period was used to simulate stable HPO MCRT, low DAR MCRT, and variable flow and loading.
- Period 2: October 2009 through April 2010. This period was used to simulate stable HPO MCRT, variable DAR MCRT, and stable flow and load.
- Period 3: January 2012 through June 2012. This period was used to simulate stable HPO MCRT, High DAR MCRT, and stable flow and load.

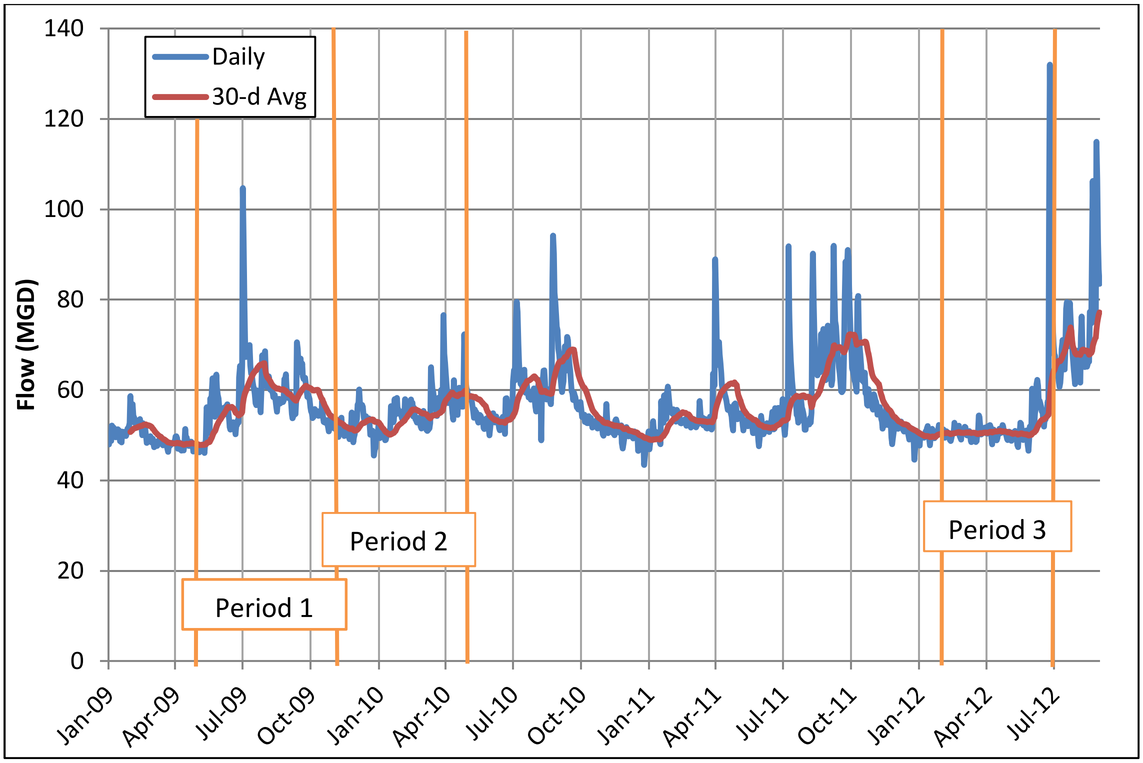

Figure 2
Historical Flow at HFCAWTP from January 2009 through August 2012

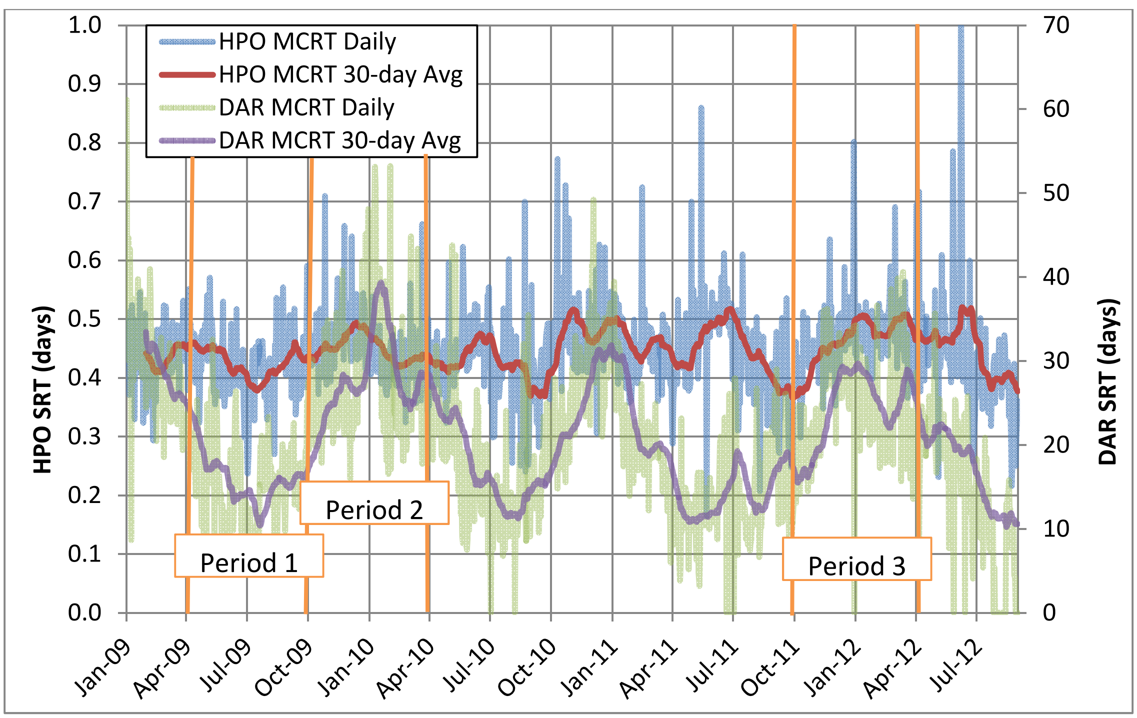

Figure 3
SRT for HPO and DAR from January 2009 through August 2012

DRAFT

The HFCAWTP monitors wastewater characteristics on a daily basis at the influent, primary effluent, HPO effluent, and DAR effluent. For each of the points in the process, data is analyzed for the following parameters: flow, five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), ammonia (NH_3), Total Kjeldahl Nitrogen (TKN), and nitrate plus nitrite (NO_x or NO_3+NO_2). The actual historical daily primary effluent data was input into the GPS-X model for each calibration period. In addition to the wastewater characterization data, the model used actual daily process control data to simulate actual operating conditions. The effluent conditions predicted by the model were then compared to the actual conditions. The model's influent characterization (including fractionation), biokinetic, stoichiometric, and settling parameters were modified to minimize the difference between (i.e. calibrate) the model's predicted effluent conditions to the actual effluent conditions to improve the accuracy of the simulations.

A summary of the results for the modeling calibration is provided in Table 1 and

Table 2. The summary tables compare the model's simulated effluent values for BOD_5, TSS, and nitrogen species with the actual effluent values for the same period. The percentiles were included to demonstrate how closely the model was able to predict high and low values in addition to the average value.

Table 1
Summary of Modeling Calibration Results for HPO Reactor

Parameter		HPO Eff. BOD_5		HPO Eff. TSS		HPO Eff. NH_3-N		HPO Eff. TKN		HPO Eff. NOx-N	
		Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)
Period 1	Average	25	33.5	9.0	21.0	13.2	16.3	15.5	20.4	10.6	11.0
	95th Percent	43	45.6	17.3	27.5	17.4	22.6	19.9	27.5	13.1	17.7
	90th Percent	37	41.5	13.6	26.1	16.3	20.9	18.9	26.1	12.4	15.9
	75th Percent	31	36.8	9.6	21.3	14.8	17.3	16.9	21.3	11.5	12.1
	25th Percent	18	29.9	6.4	17.9	11.6	14.1	13.6	17.9	9.8	8.9
	10th Percent	11	26.7	5.6	16.8	10.3	12.8	12.3	16.8	8.9	7.6
	5th Percent	7	25.8	4.8	15.5	9.2	12.2	11.4	15.5	8.2	6.7
Period 2	Average	33	27.0	9.0	12.53	16.9	17.3	19.4	20.4	9.3	9.7
	95th Percent	54	40.3	15.2	13.2	22.7	21.0	25.5	24.4	12.2	13.7
	90th Percent	51	35.4	13.2	13.0	20.4	20.2	23.0	23.1	11.8	12.7
	75th Percent	39	30.1	10.4	12.7	18.4	18.9	20.9	21.9	11.2	11.3
	25th Percent	24	22.5	6.8	12.3	14.7	16.2	17.0	19.0	8.6	8.3
	10th Percent	18	20.7	5.2	12.1	13.8	14.6	16.1	17.4	5	7.2
	5th Percent	15	18.6	4.8	12.0	13.3	13.2	15.6	16.0	3.3	6.3
Period 3	Average	33	23	7.9	12.3	20.7	18.4	23.4	21.4	7.3	10.8
	95th Percent	57	35	15.2	12.7	25.7	24.0	28.1	27.4	10.2	17.5
	90th Percent	49	31	12.8	12.4	24.2	22.7	26.8	25.8	9.3	15.8
	75th Percent	40	25	8.8	12.3	22.7	20.7	25.2	23.6	8.4	12.9
	25th Percent	24	19	5.2	12.05	19.5	15.9	22.1	18.7	6.3	8.5
	10th Percent	17	17	4.0	11.8	18.0	13.6	20.1	16.4	5.6	6.4
	5th Percent	13	17	3.6	11.7	15.2	11.6	18.2	14.4	3.1	5.3

Table 2
Summary of Modeling Calibration Results for DAR Reactor

	Parameter	DAR Eff. BOD_5		DAR Eff. TSS		DAR Eff. NH_3-N		DAR Eff. TKN		DAR Eff. NOx-N	
		Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)	Actual (mg/L)	Model (mg/L)
Period 1	Average	4.4	N/A	7.3	9.9	<0.24	0.25	1.33	1.47	24.2	27.2
	95th Percent	5.1	N/A	11.3	11.3	0.70	0.25	1.63	1.61	30.2	38.2
	90th Percent	4.9	N/A	9.6	11.1	<0.24	0.23	1.58	1.55	29.3	34.5
	75th Percent	4.6	N/A	8	10.8	<0.24	0.20	1.49	1.51	26.0	28.2
	25th Percent	4.0	N/A	6.2	8.7	<0.24	0.16	1.16	1.27	21.9	23.8
	10th Percent	3.8	N/A	4.9	8.2	<0.24	0.15	1.01	1.21	19.9	22.1
	5th Percent	3.8	N/A	4.4	8.2	<0.24	0.14	0.98	1.21	18.3	21.2
Period 2	Average	5.4	N/A	6.3	9.5	<0.24	0.25	1.2	1.5	26.0	26.8
	95th Percent	6.2	N/A	9	11.0	<0.24	0.37	1.5	1.76	30.0	30.5
	90th Percent	6.0	N/A	8.8	10.7	<0.24	0.35	1.4	1.72	29.1	29.8
	75th Percent	5.8	N/A	7.6	10.3	<0.24	0.29	1.3	1.65	28.0	28.5
	25th Percent	4.9	N/A	4.6	8.7	<0.24	0.20	1.1	1.41	24.1	25.3
	10th Percent	4.5	N/A	3.4	8.0	<0.24	0.18	1.0	1.27	22.8	24.3
	5th Percent	4.2	N/A	2.8	7.5	<0.24	0.17	1.0	1.22	22.1	23.0
Period 3	Average	5.7	N/A	8.3	7.1	<0.24	0.22	1.28	1.26	28.1	29.7
	95th Percent	6.3	N/A	12.2	8.7	<0.24	0.33	1.65	1.47	32.6	34.4
	90th Percent	6.2	N/A	10.6	8.1	<0.24	0.29	1.55	1.41	31.9	33.4
	75th Percent	5.9	N/A	9.6	7.6	<0.24	0.23	1.4	1.33	30.4	32.3
	25th Percent	5.4	N/A	6.6	6.6	<0.24	0.17	1.13	1.15	26.8	28.0
	10th Percent	5.1	N/A	5.4	6.4	<0.24	0.16	1.01	1.13	24.5	26.0
	5th Percent	5.0	N/A	4.8	6.3	<0.24	0.16	0.97	1.11	21.6	22.2

Calibration was performed with a focus on achieving a relatively accurate but conservatively high simulation of effluent nitrogen species concentrations. Less accuracy was allowed for BOD_5 and TSS as they are less critical to the DAR aeration design. The modeling calibration was able to achieve a reasonable degree of calibration over the three calibration periods. Details on the calibration modeling including the values for all biokinetic, stoichiometric, and operational parameters can be found in Appendix A of this memorandum. In addition to the printed Appendix A, the complete modeling reports are provided electronically on a CD. Each complete modeling report includes model inputs and detailed output.

3.0 Alternatives Analysis Modeling

The calibrated GPS-X model was used to model the nitrification and denitrification for the 4 alternatives discussed in Section 1.1. The current 57 MGD AADF operation at the HFCAWTP has used 2 HPO reactors and 3 DARs. For each alternative, the model was run at 5 MGD flow increments from 57 to 96 MGD to predict overall performance as flows increase and additional reactors should be placed into service.

3.1 Alternative 1 – Baseline Conditions

The purpose of the first alternative is to set the baseline conditions based on the current operation of the HPO and DARs with no intentional denitrification at the HPO or DAR basins. For this scenario denitrification would take place in the denitrification filters. The following assumptions were used for Alternative 1 modeling:

- The solids retention time (SRT) in the HPO reactors was limited to less than 2 days and HPO MLSS to no more than 2500 mg/L. According to operations staff experience, operating at a higher SRT results in poor settleability.
- The maximum mixed liquor suspended solids (MLSS) concentration in the DARs was 3,600 mg/L. It was assumed that a greater MLSS concentration could result in exceeding the solids loading rate of the DAR clarifiers.
- The spike line that bypasses the HPO reactor operates at 3% of the influent flow. The spike line provides a source of carbon to promote the growth of heterotrophic bacteria in the DARs to improve floc formation and settleability.
- Initially two HPO reactors and four DARs were online. As flows increased, an additional HPO reactor was put online as needed to maintain the HPO MLSS concentration at no more than 2,500 mg/L.

The primary effluent loadings used for modeling Alternative 1 were monthly average values from the historical data from January 2009 through August of 2012. The characterization fractions determined during the model calibration were used for each month. In addition to influent characteristics, operating parameters were also input into the model to simulate actual conditions. To simulate settleability, the actual monthly average sludge volume index (SVI) was used for both the HPO and the DAR clarifiers. The monthly average SRT of the DAR basins was also used to simulate typical seasonal operational changes. The monthly average primary effluent and operational parameters used for the Alternative 1 simulation are summarized in Table 3.

Table 3
Alternative 1 Modeling Inputs

Month	PE cBOD5 (mg/L)	PE TSS (mg/L)	PE TKN (mg/L)	PE Temp (°C)	HPO SVI (mL/g)	DAR SRT (days)	DAR SVI (mL/g)
Jan	166	96	42.8	22	156	35	61
Feb	160	89	43.3	22	150	29	56
Mar	153	90	42.7	24	159	29	57
Apr	150	94	40.9	26	166	23	55
May	150	130	43.3	28	165	22	58
Jun	124	87	37.6	29	173	21	57
Jul	96	79	30.0	29	160	17	50
Aug	92	78	28.5	29	157	19	50
Sep	91	76	29.2	29	159	22	48
Oct	109	72	35.0	28	160	27	52
Nov	134	107	41.0	26	173	32	54
Dec	141	80	40.8	24	172	35	58

3.1.1 Modeling Results

Modeling runs were performed at flow rates from 57 MGD (the current AADF) to 96 MGD on an AADF basis in increments of 5 MGD. The simulated performance of the plant is summarized in Table 4 and

Table 5 for the HPO reactors and DARs respectively for each flow rate. The tables present the average of the 365 days model for each set of reactors. For the results of individual months, refer to the modeling reports contained in the CD associated with this memorandum. The aeration horsepower was not optimized for this modeling. It was assumed that the DO in all zones of the DARs was maintained at 2.0 mg/L.

Table 4
Alternative 1 Modeling Results Summary HPO Reactors

Average Annual Flow Rate (MGD)	Basins Online	SRT (days)	Avg. MLSS (mg/L)	Avg. Aerator Power (bhp)	Avg. $cBOD_5$ (mg/L)	Avg. TSS (mg/L)	Avg. NO_X (mg-N/L)	Avg. NH_3 (mg-N/L)
57	2	0.58	1,390	370	17	12	8.0	19.3
62	2	0.53	1,390	370	24	12	6.5	20.6
67	2	0.49	1,390	370	27	12	6.0	21.1
72	2	0.62	1,490	370	25	12	7.0	20.2
77	3	0.75	2,200	555	23	13	7.4	19.8
82	3	0.99	2,290	555	15	15	9.1	17.8
87	4	1.00	1,800	740	15	14	7.7	19.1
92	4	1.00	1,810	740	15	14	7.5	19.7
96	4	1.06	2,100	740	16	14	8.2	18.6

Table 5
Alternative 1 Modeling Results Summary DARs

Average Annual Flow Rate (MGD)	Basins Online (1)	Avg. MLSS (mg/L)	AOR (lb 0_2/day)	Avg. $cBOD_5$ (mg/L)	Avg. TSS (mg/L)	Avg. TKN (mg-N/L)	Avg. NO_X (mg-N/L)	Avg. NH_3 (mg-N/L)
57	4	1,480	46,300	5.2	5.7	1.30	26.6	0.42
62	4	1,690	53,800	5.6	7.3	1.47	26.1	0.47
67	4	1,910	60,500	6.0	8.1	1.59	26.0	0.52
72	4	2,150	60,500	6.3	8.9	1.62	26.1	0.47
77	4	2,055	63,600	6.4	9.1	1.66	26.3	0.51
82	4	2,300	61,300	4.8	6.3	1.46	26.1	0.56
87	4	2,455	67,000	6.3	9.1	1.78	25.9	0.64
92	4	2,565	72300	6.4	10.1	1.76	27.5	0.31
96	4	2,890	75800	6.4	11.5	1.80	27.7	0.29

(1) The DARs were controlled based on SRT input from average monthly operational data as described in Table 3

The modeling confirmed that the HFCAWTP can treat flows to the permitted capacity of 96 MGD without the need for construction of additional HPO or DAR basins. The modeling also indicated that a third HPO basin will need to be put online before flows reach 77 MGD AADF and a fourth basin would be needed before flows reach 87 MGD AADF.

3.2 Alternative 2 – Denitrification in DARs with Current HPO Operation

The purpose of the second alternative is to model the potential benefits of operating the DARs to achieve some denitrification upstream of the denitrification filters. Modeling performed for Alternative 1 indicated that January was the most difficult month to remove ammonia due to the relatively high ammonia load, cold temperature, and high mixed liquor concentration required in the DAR. For Alternative 2, the modeling was performed using the January conditions as the “worst case”. Although the current AADF is 57 MGD, the highest January monthly average flow from 2009 through 2012 was 52 MGD due to less infiltration and inflow during that month than on average over the entire year. Although the January flow is lower than the AADF, January is representative of the “worst case” month because the maximum monthly loadings occur when the influent wastewater temperatures are the coldest and the bio-kinetic rates are the slowest.

3.2.1 Effluent Sensitivity Analysis

Initial modeling for Alternative 2 was to determine which operational changes have the greatest impact on the performance of denitrification by performing sensitivity analyses. The first step was to establish a baseline condition with no denitrification as presented by Figure 4. This figure demonstrates that if the DARs were continuously aerated, the effluent NOx concentration for the maximum month condition would be approximately 32.3 mg/L with non-detectable NH_3 concentrations, and a TKN of 1.0 mg/L. Base modeling conditions also included 2 HPO basins and 4 DAR basins in service.

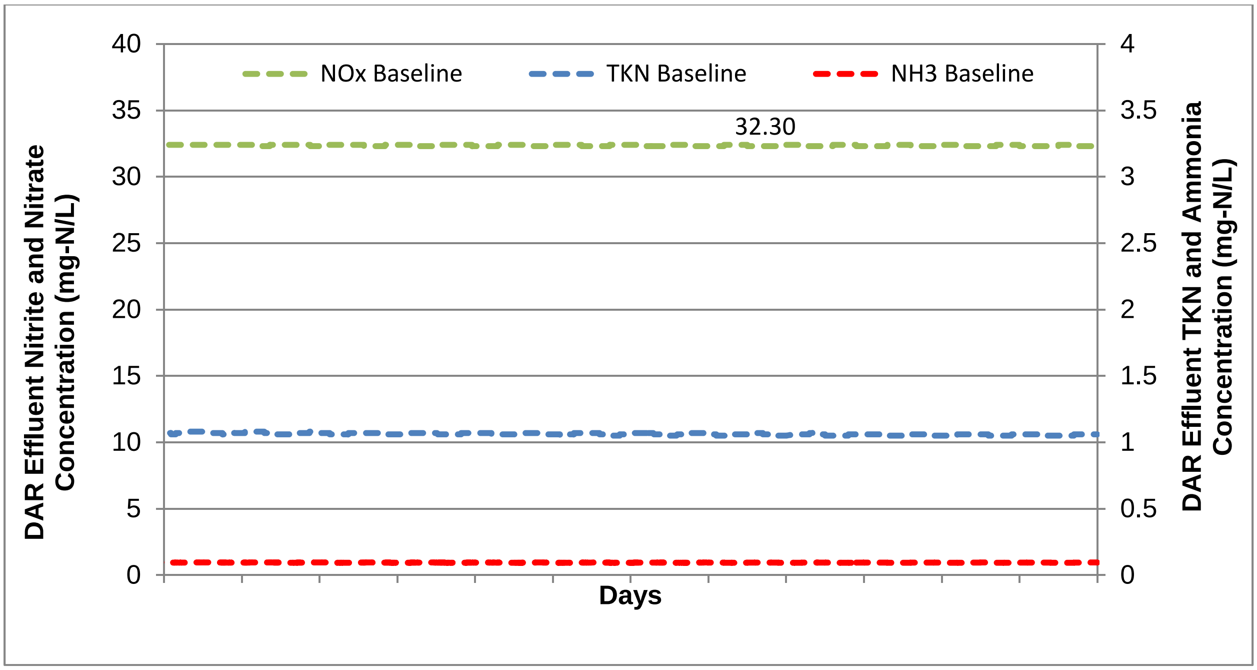

Figure 4
Alternative 2 Sensitivity Analysis: Base Conditions

One of the most important operational parameters that will have an effect on the amount denitrification achieved in the DAR is based on the amount of carbon added via the spike line. More carbon (via more spike flow) to the DARs will increase the amount of denitrification. However, adding more spike flow will increase the heterotrophic biomass which will decrease the autotrophic biomass available for nitrification given the same MLSS concentration. Consequently, increasing denitrification by adding spike flow limits the DARs nitrification capacity and modeling was used to find the appropriate balance.

All of the modeling for Alternative 2 was performed using on/off aeration for denitrification. The DARs were modeled with all 4 trains in operation using on/off aeration in the first 5 zones starting with a 4 hour on and a 4 hour off cycle time. The sixth zone was always aerated to minimize DAR effluent ammonia and to strip the nitrogen gas generated by denitrification. To balance the air flow rate, trains 1 and 3 were operated with the same on/off timing and trains 2 and 4 were operated with the same timing but opposite trains 1 and 3. After the cycle time, the zones that are unaerated are aerated and vice versa so that as one train decreases aeration the other train increases aeration thereby avoiding a step change in the air demand at the blowers. The on/off cycling for each zone modeled is shown in Figure 5.

Figure 5
Alternative 2 On/Off Aeration Strategy

A sensitivity analysis was performed by varying the spike flow as a percent of influent flow. Flow rates of 10%, 20%, and 30% were modeled to determine the increase in denitrification with increased spike flow. The results of the sensitivity analysis for the various spike flows are shown in Figure 6.

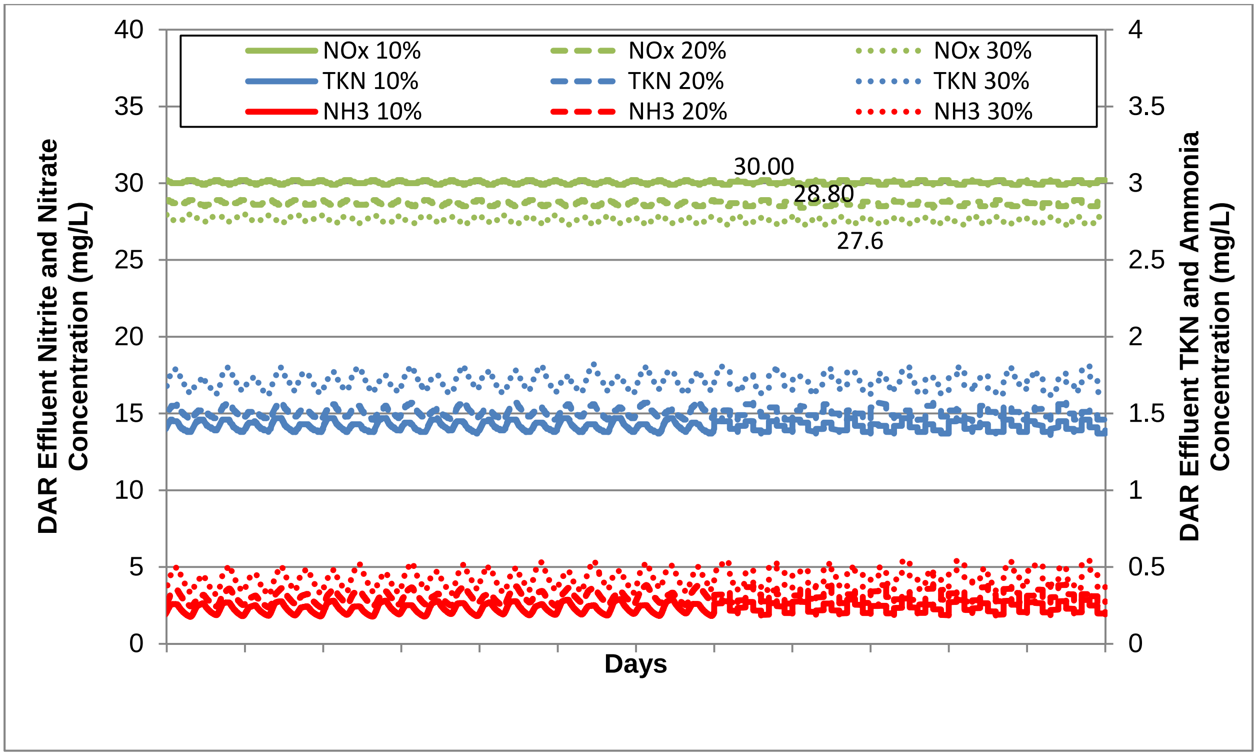

Figure 6
Alternative 2 Sensitivity Analysis: Spike Flow to DARs

The results of the spike flow sensitivity analysis showed that the proportion of spike feed has a large effect on the amount of denitrification in the DARs. The first 10% produced 2.3 mg/L of denitrification. For each additional 10% of spike flow, 1.2 mg/L of nitrate was denitrified so at a 30% spike flow, approximately 4.7 mg/L of nitrate was denitrified. (The modeling showed that instead of being near zero, the nitrate concentration leaving the first and second zone was 18 mg/L indicating that carbon is the limiting factor for denitrification at the DARs. This implies that static anoxic zones would be no more effective than on/off aeration which was later confirmed by additional modeling.

Considering that denitrification at the DARs is carbon limited, a sensitivity analysis was performed to determine the effect HPO reactors had on the denitrification rate. More HPO reactors online would result in lower effluent BOD and therefore less denitrification would occur in the DARs. The sensitivity analysis was run with 2 and 3 HPO reactors online. For each of these model runs, the DARs were operated using an on/off aeration sequence with 4 hours on and 4 hours off and a spike flow of 30%. The results for the HPO operation sensitivity analysis are presented in Figure 7.

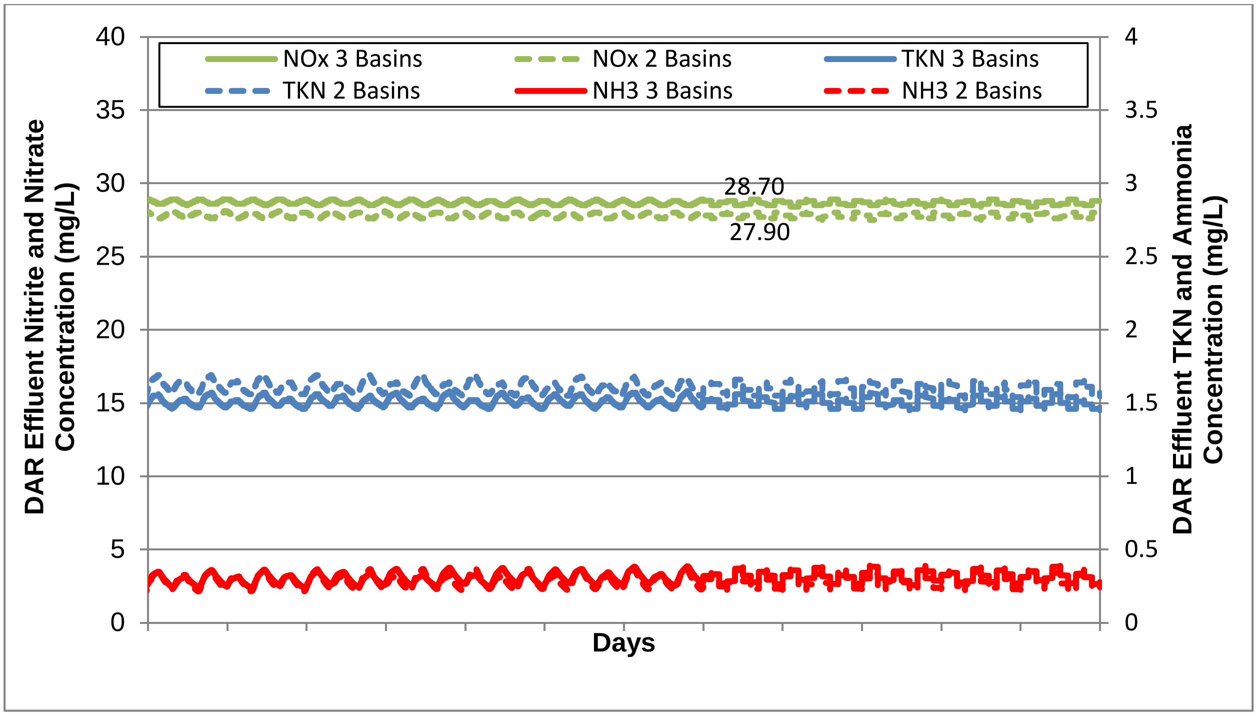

Figure 7
Alternative 2 Sensitivity Analysis: HPO Basins Operational

This sensitivity analysis showed that the number of HPO basins in operation has little effect on denitrification in the DARs. The mass of BOD in the effluent from HPO reactors is relatively small as long as the reactors are used for carbon removal. It is difficult to reduce the carbon removal performance of the HPO reactors while maintaining good settleability in the HPO system. It is possible that operating 1 HPO reactor instead of 2 reactors would increase the HPO effluent BOD; however, if the SRT in the HPO is too low the microorganisms might not flocculate well and settling will be negatively affected.

The last sensitivity analysis performed was on the timing of the on/off aeration pattern. The longer the air is off the more denitrification will occur; however, this must be balanced with providing enough time for adequate aeration for nitrification. Even without BOD available for denitrification endogenous respiration will occur within the biomass which will release additional BOD for use for denitrification. The process of endogenous respiration is slow; therefore, the rate of denitrification decreases from the upstream end to the downstream end of the reactors.

Three model runs were performed to evaluate the sensitivity of on/off timing on denitrification performance. The first model run used the timing that aerated the zones 66% of the time leaving 33% of the time unaerated for denitrification. The second model run used a 50% on and off timing strategy. The third model run used a static anoxic zone at the head of the DARs then aerated the remaining tanks 66% of the time. The spike flow for each of these model runs was 30% of the influent flow. The results of the aeration timing sensitivity analysis are presented in Figure 8.

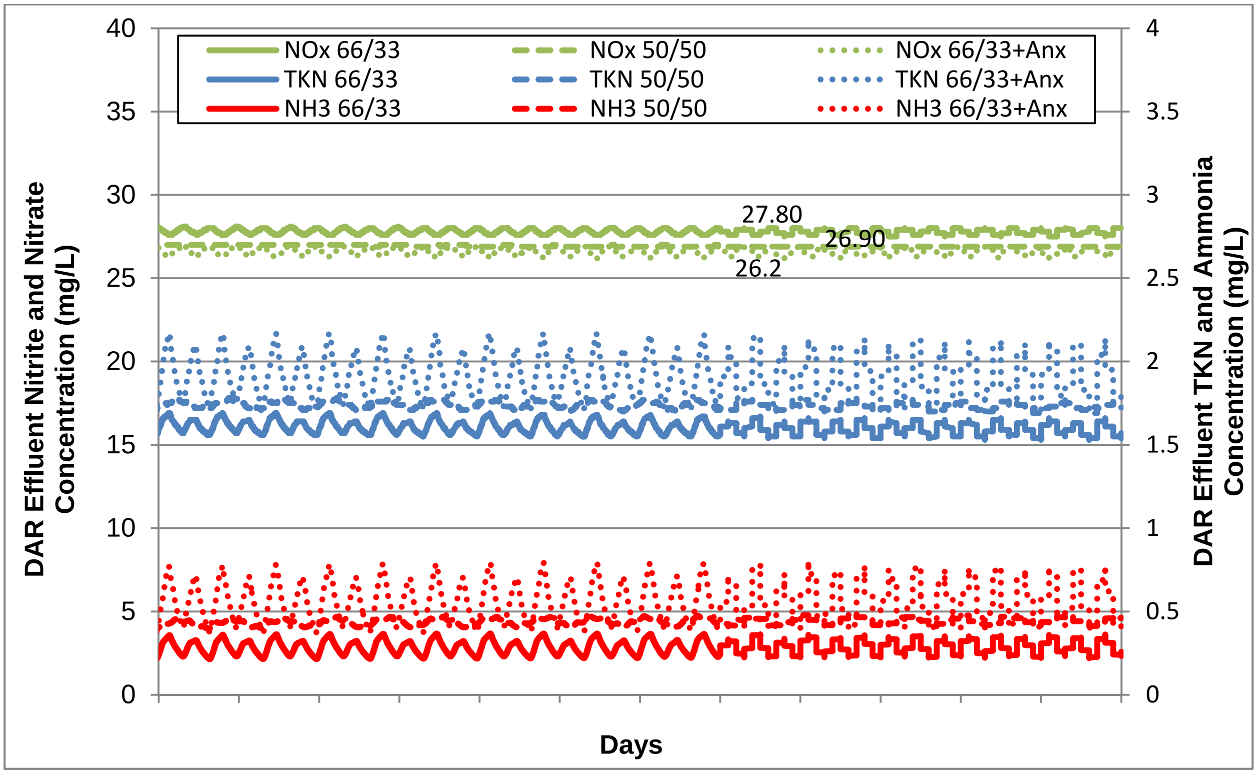

Figure 8
Alternative 2 Sensitivity Analysis: On-Off Timing In DARs

The results of the aeration timing sensitivity analysis show that the 50/50 on-off aeration timing provides the lowest nitrate effluent without exceeding the 0.8 mg-N/L ceiling for ammonia and 2.0 mg/L ceiling for TKN. The model run including the fixed anoxic zone produced a slightly lower nitrate level but could not nitrify sufficiently to comply with the ammonia and TKN ceilings.

3.2.2 Modeling Results

The sensitivity analyses identified that controlling the carbon going to the DARs is the key parameter to maximize denitrification in the DARs. The mass of carbon sent to the DARs can be increased by increasing the flow in the spike line that bypasses the HPO reactors or by diminishing the performance of the HPO reactors. The removal efficiency for the HPO reactors increases with more reactors online and a longer SRT in the reactor. As flows increase, the City should defer increasing the SRT in the HPO reactors or putting more HPO reactors online as long as possible based on the DAR's nitrification ability and the settleability of the HPO sludge. There is also diminishing denitrification benefit of turning air off in the downstream zones in the DARs because less carbon will be available. Operational changes in the modeling were made using the following rationale which is intended to optimize carbon use throughout the two reactors:

1. The DAR SRT was adjusted to maintain the MLSS concentration at approximately 3,500 mg/L.
2. The spike fraction was maximized (up to 30%) to provide as much carbon as possible to the DARs while maintaining effluent ammonia concentrations at 0.8 mg-N/L or less.
3. The amount of time the air was kept on in the in aeration zones 4 and 5 was increased as needed to maintain effluent ammonia concentrations at below 0.8 mg-N/L.
4. The spike fraction was decreased when SRT could not support nitrification below 0.8 at a mixed liquor concentration less than 3,500 mg/L.

Several iterations of the model were performed based on the guidance derived from the sensitivity analyses. The goal of these modeling runs was to determine the operating conditions at the HPO and DAR reactors that would result in as much denitrification as possible with very little sacrifice in nitrification performance. Tables 6, 7, and 8 summarize the operating conditions identified as optimal in this respect.

As shown in Table 6, just 2 HPO reactors are recommended up to an influent flow rate of 82 MGD AADF. At greater flows a third HPO reactor should be used and will meet the need at flows up to and including the 96 MGD AADF capacity rating. With this operating approach, the HPO SRT will remain at less than 2 days and the ammonia concentration out of the HPO reactors will be just less than 20 mg-N/L.

Table 6
Alternative 2 Modeling Results Summary HPO Reactors

Average Annual Flow Rate (MGD)	Basins Online	SRT (days)	Avg. MLSS (mg/L)	Avg. Aerator Power (bhp)	Avg. $cBOD_5$ (mg/L)	Avg. TSS (mg/L)	Avg. NO_X (mg-N/L)	Avg. NH_3 (mg-N/L)
57	2	0.86	1,100	360	21	11	12.9	18.0
62	2	1.11	1,200	360	21	11	11.9	19.0
67	2	1.14	1,300	360	21	11	11.4	19.4
72	2	1.30	1,440	390	21	12	11.7	19.0
77	2	1.40	1,640	410	19	12	13.7	17.3
82	2	1.35	1,840	410	20	13	11.0	19.9
87	3	1.42	1,340	560	19	13	11.6	19.3
92	3	1.66	1,740	563	19	14	11.0	19.7
96	3	1.78	2,030	583	18	15	12.0	18.4

Together Tables 7 and 8 describe the recommended operation of the DAR basins under this Alternative. Table 7 shows the recommended on-off timing of aeration cycles for each of the six aeration zones in the each of the four DAR basins. Table 8 shows simulated effluent quality along with the recommended spike flow, SRT and MLSS at each influent flow rate. At the current AADF of 57 MGD and up to 67 MGD, the 50%/on/50% off aeration cycle implemented as 4 hours with aeration on followed by 4 hours of aeration off repeatedly would provide improved denitrification without a significant loss of nitrification. At AADF greater than 67 MGD, additional nitrification is required to maintain ammonia below the 0.8 mg-N/L ceiling.

The benefit of using on/off aeration is that the aeration times are completely controllable and reversible. If additional nitrification is required, additional aeration time can be provided in downstream DAR zones without significantly reducing overall denitrification performance. To meet that need at flows greater than 67 MGD, the aeration cycle in the downstream zones (zones 4 and 5) should be modified to 75% air on (for nitrification) and just 25% air off (for denitrification). This was simulated as a cycle of 6 hours on/2 hours off. At greater than 92 MGD AADF, the model indicated that Zones 4 and 5 should be aerated continuously to increase nitrification to provide an effluent ammonia concentration less than 0.8 mg-N/L.

Table 7
Alternative 2 Modeling Results for Aeration Timing in DARs

Average Annual Flow Rate (MGD)	Zone 1 Time on/off (hours)	Zone 2 Time on/off (hours)	Zone 3 Time on/off (hours)	Zone 4 Time on/off (hours)	Zone 5 Time on/off (hours)	Zone 6 Time on/off (hours)
57	4/4	4/4	4/4	4/4	4/4	24/0
62	4/4	4/4	4/4	4/4	4/4	24/0
67	4/4	4/4	4/4	4/4	4/4	24/0
72	4/4	4/4	4/4	6/2	6/2	24/0
77	4/4	4/4	4/4	6/2	6/2	24/0
82	4/4	4/4	4/4	6/2	6/2	24/0
87	4/4	4/4	4/4	6/2	6/2	24/0
92	4/4	4/4	4/4	6/2	6/2	24/0
96	4/4	4/4	4/4	24/0	24/0	24/0

At 77 MGD AADF or less, performance is limited not by nitrification but by the availability of carbon to denitrify so the spike line flow should be maintained at the maximum 30% of influent flow. As the AADF increases and more of the DAR must be operated aerobically the potential for denitrification is decreased so less carbon in needed from the spike line. The simulations indicated that spike flow should be reduced to 25% above 77 MGD AADF and to 20% for flow greater than 87 MGD AADF. Across the entire range of flows the mixed liquor concentration should be maintained at approximately 3500 mg/L to maximize the biomass available for nitrification and denitrification without overloading the clarifiers.

Table 8
Alternative 2 Modeling Results Summary DARs

Average Annual Flow Rate (MGD)	Spike Fraction	SRT (days)	Avg. MLSS (mg/L)	AOR (lb 0_2/day)	Avg. $cBOD_5$/TSS (mg/L)	Avg. TKN (mg-N/L)	Avg. NO_X (mg-N/L)	Avg. NH_3 (mg-N/L)
57	0.3	20	3,300	57,000	7.1/11.0	1.93	24.9	0.67
62	0.3	22	3,600	63,600	7.5/12.0	2.02	24.7	0.70
67	0.3	20	3,500	68,800	7.8/11.9	2.15	24.5	0.81
72	0.3	18	3,400	75,000	8.2/12.0	1.88	25.8	0.52
77	0.3	18	3,400	76,800	8.5/12.4	1.95	26.2	0.52
82	0.25	23	3,600	83,600	8.6/13.1	1.96	26.6	0.49
87	0.25	21	3,480	85,800	8.9/13.1	2.03	26.6	0.53
92	0.2	24	3,580	87,000	8.7/13.7	2.03	27.1	0.53
96	0.2	22	3,450	90,000	8.9/13.6	1.83	27.7	0.31

Following the operating recommendations in Tables 7 and 8, ammonia nitrogen would remain at or less than 0.8 mg/L over the entire AADF range. Nitrate would be below 25 mg/L at AADFs up to 67 MGD and would gradually increase up to approximately 27.7 mg-N/L at the 96 MGD AADF rating. Comparing to the 32.2 mg-N/L nitrate achieved at a 57 MGD AADF without on-off aeration, the nitrate to be denitrified in the filters would be decreased by between 7.7 to 4.5 mg-N/L (a 14-24% reduction) thereby decreasing the methanol required as carbon source at the filters. At the same time decreasing aeration from 100% over all 6 zones to just Zone 6 at 100% aeration and Zones 1-5 at just 50% aeration will decrease the energy required for aeration.

3.2.3 Economic Evaluation

Tetra Tech performed a life cycle cost analysis to evaluate the total life cycle savings for rehabilitating the HPO basins, replacing the aeration system in the DARs, and implementing an on/off aeration strategy in the DARs. The evaluation included the initial capital cost and operations and maintenance costs for the HPO reactors, DARs, and denitrification filters for a 20-year period. The mass of nitrate denitrified in the DARs was subtracted from the nitrate used to determine the methanol demand for the denitrification filters.

In January 2012, Greeley and Hansen prepared two technical memorandums that evaluated the HPO reactors. The evaluation estimated the capital and operations and maintenance costs for rehabilitating the HPO reactors and the cryogenic oxygen generation system. Tetra Tech used these Greeley and Hansen estimates as the basis for the capital costs for economic evaluation. The HPO reactor rehabilitation was assumed to include replacement of surface aerators in three reactors, rehabilitation of the cryogenic oxygen system, cleaning the basins, enlarging the openings between reactor zones, replacement of baffles, and replacement of piping from the main pumping station.

For the DAR modifications, Tetra Tech included replacing the diffusers, valving required for on/off aeration, electrical improvements, instrumentation and control improvements, and SCADA modifications to incorporate on/off aeration controls. Mixers in each zone were also included in the initial opinion of probable construction cost (OPC) for the project in the event mixers are needed during off cycles. Tetra Tech will evaluate the need for these mixers during the detailed design, although at this time it is Tetra Tech's opinion that these mixers will not be required. The capital cost reflected in the analysis is based on using Ovivo membrane panels which was the City's preferred aeration technology identified in Tetra Tech's Dissolved Aeration System Replacement Alternatives memorandum.

The OPC estimates the HPO rehabilitation will cost $10.1 million and the DAR aeration improvements will cost $4.7 million for a total project cost of $14.8 million. Of the $4.7 million for DAR aeration improvements approximately $1.7 million is required for implementing on/off aeration. Detailed OPCs are presented in Appendix B of this memorandum.

A dynamic life cycle cost evaluation was performed to evaluate the life cycle cost of aeration cost for the HPO reactors and DARs, and the chemical (methanol) costs for the denitrification filters. The dynamic life cycle cost evaluation includes projected increases in flows starting at the current flow of 57 MGD. As determined through modeling there is a slight decrease in denitrification performance as flows increase due to the need to aerate more volume in the DARs to maintain nitrification performance. By evaluating operating costs on a yearly basis, flow and denitrification performance changes are taken into account, and the life-cycle cost analysis is more representative. The evaluation includes a scheduled replacement of the diffuser membranes after 10 years of operation. An assumed inflation rate of 3% annually was used for all electricity, chemical, and future capital costs. The evaluation estimated the total 20 year cost of Alternative 2 at $137.7 million. The detailed life cycle cost analysis is found in Appendix B.

Based on current flows, denitrification in the DARs results in savings of approximately $651,000 in the first year of which $587,000 is methanol cost savings and $64,000 is aeration costs savings. The operational savings will pay for the entire aeration improvement project in 7.2 years. If the operational savings are compared to only the incremental cost of implementing on/off aeration, there is a payback of 2.6 years. Over 20-years the projected savings in chemical and electricity costs is $20.0 million. Without denitrification in the DARs, the total estimated life cycle cost is $157.7 million.

3.3 Alternative 3 – HPO Conversion to CAS with Denitrification in DARs

The purpose of the third alternative is to model the potential benefits for converting the HPO basins to operate as conventional (aerated) activated sludge (CAS) while also operating the DARs to achieve some denitrification upstream of the denitrification filters. The purpose would be two-fold: to allow the costly to operate and maintain oxygen generating units to be shut down and to provide more flexibility in the operation of the first stage process for CBOD removal. As with Alternative 2 the modeling was performed using January conditions as the "worst case".

3.3.1 Effluent Sensitivity Analysis

Initial modeling for Alternative 3 was to determine which operational changes have the greatest impact on the performance of denitrification by performing sensitivity analyses. The first step was to consider the effect of the SRT used in the first stage (the CAS in this alternative) on the nitrification and denitrification performance of the DARs in the second stage. Figure 9 demonstrates that a CAS SRT of 0.5 day yields a significantly lower nitrate concentration as compared to a CAS SRT of either 1.0 day or 2.0 days. At the same time the DAR effluent ammonia concentration increases only a fraction of a mg/L. The improved denitrification at the DARs simulated by the model when using short CAS SRT is related to more CBOD passing from the CAS basins to the DARs. In a single stage process, degraded performance of the CAS at short SRT would be a problem but for the two stage system at HFCAWTP the degraded CBOD removal at stage 1 could result in more CBOD supplied to the DARs where it supplements the spike line to provide carbon source for denitrification.

These modeling results should be interpreted with caution as the model is actually indicating that the CBOD has not been metabolized in Stage 1 but much of it may well have been adsorbed to the biomass (some externally and some internally). The absorption mechanism is not well represented by GPS-X or most or other process models. Although the adsorbed CBOD could be used to promote denitrification under the right circumstances, most of it would it would be unavailable to the second stage (the DARs) in the overflow from the first stage clarifiers. Instead it would recycled back to the CAS with the return activated sludge (RAS) and wasted to the digesters as CAS waste activated sludge (WAS).

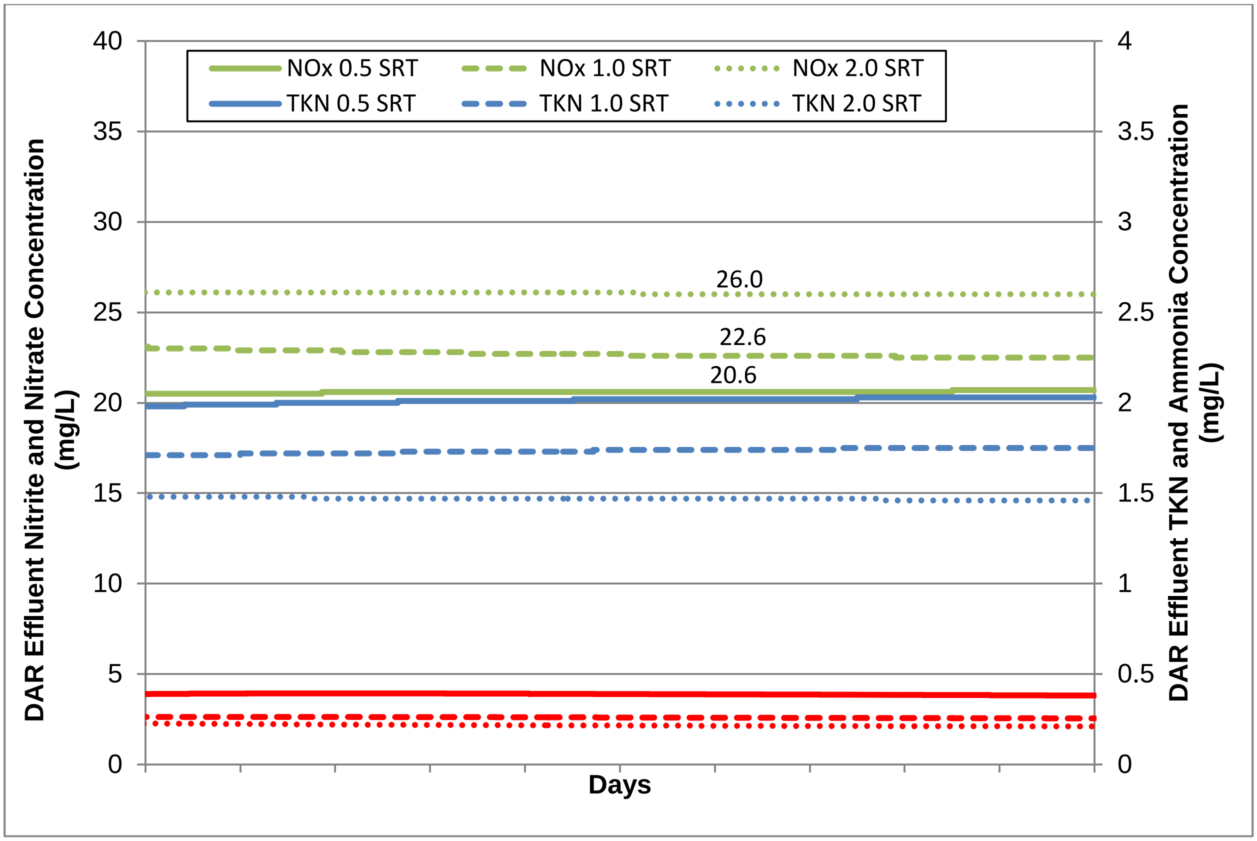

Figure 9
Alternative 3 Sensitivity Analysis: CAS SRT

As shown in Figure 10, the simulations indicate that the spike flow has little or no effect on the effluent nitrate or ammonia from the DARs when the first stage is operated as CAS. This is because the simulation is predicting that sufficient CBOD will pass from the first stage CAS directly to the DARs. As explained above, the model may well be over-predicting the CBOD that would reach the DARs from the CAS and therefore under-predicting the importance of the spike flow to deliver carbon to the DARs for denitrification.

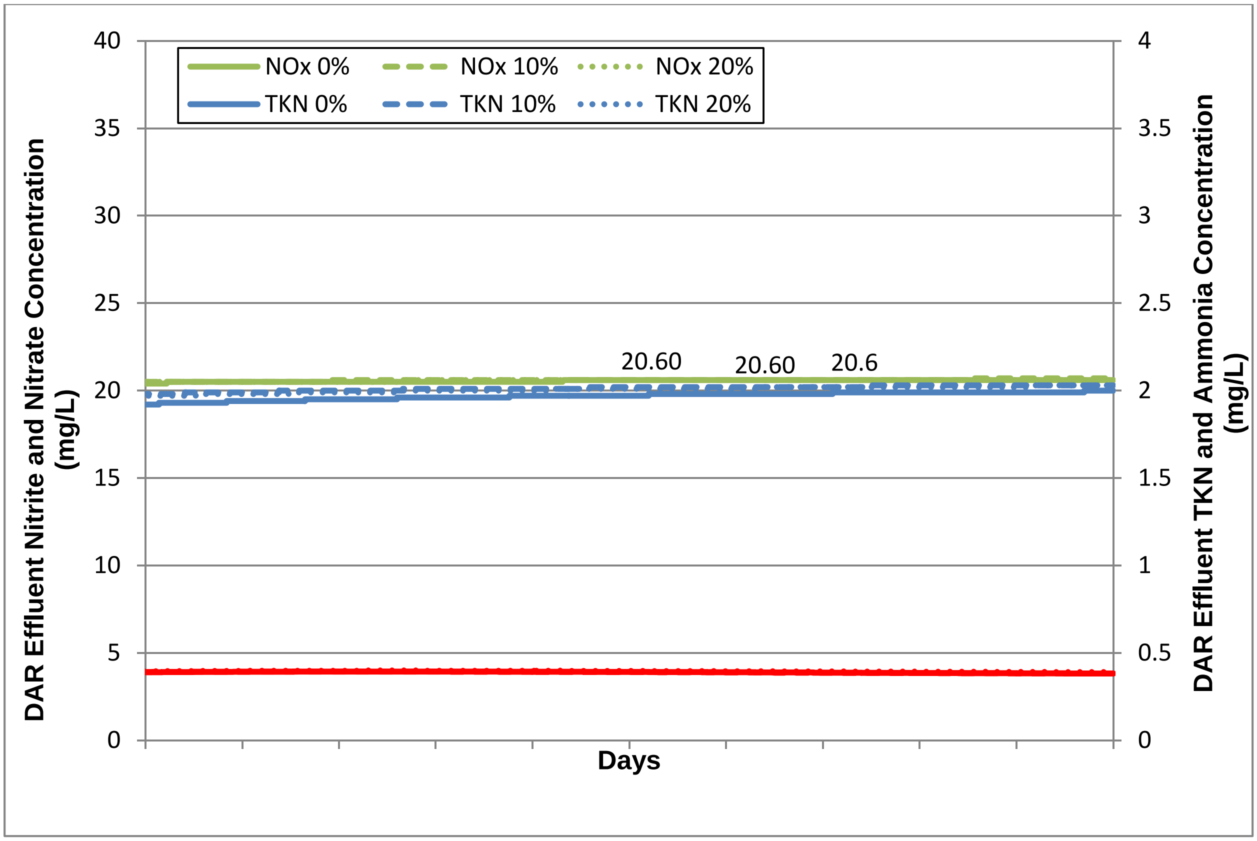

Figure 10
Alternative 3 Sensitivity Analysis: Spike flow to DARs

Similar to Alternative 2, modeling was used to investigate the benefit of using a static anoxic zone at the DARs rather than on-off aeration. As shown in Figure 11 the simulation indicates that use of static anoxic zones would out-perform on-off aeration in terms of nitrate removal if a sufficiently large loading of CBOD were to pass from the CAS to the DARs. On-off aeration and static anoxic zone approaches to denitrification at the DARs would have very similar performance with respect to ammonia. As explained above, the model may well be over-predicting the CBOD that would reach the DARs from the CAS and therefore over-predicting the benefit of static anoxic zones for denitrification at the DARs.

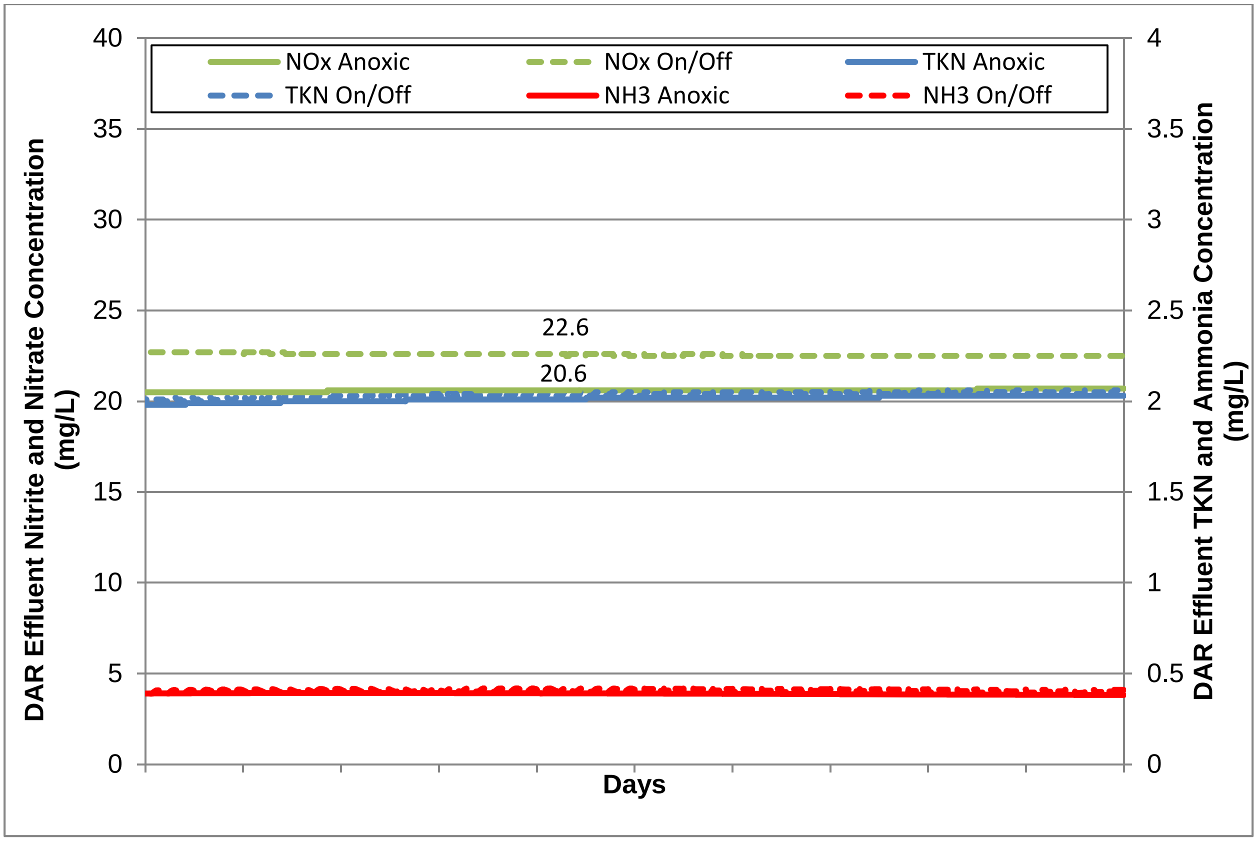

Figure 11
Alternative 3 Sensitivity Analysis: On/Off vs Static Anoxic Zone

In addition to SRT and spike flow, nitrate removal is also affected by the RAS rate used at the DARs. The nitrate concentration in the DAR RAS will be very near that of the DAR effluent and may be a significant source of nitrates for denitrification when returned to Zone 1. In this alternative, the simulation predicts a significant quantity of carbon into the DARs from the CAS basins so that he denitrification process is not carbon limited. Still, as shown in Figure 12, increasing RAS rate for 50% of the influent flow rate to 75% or 100% does not improve denitrification. In fact, the nitrate predicted at a 100% RAS rate is slightly higher than the nitrate resulting from a 50% or 75% RAS rate. As with the other results for this alternative, the model may well be over-predicting the CBOD that would reach the DARs from the CAS and therefore inaccurately simulating the effect of DAR RAS rate on denitrification.

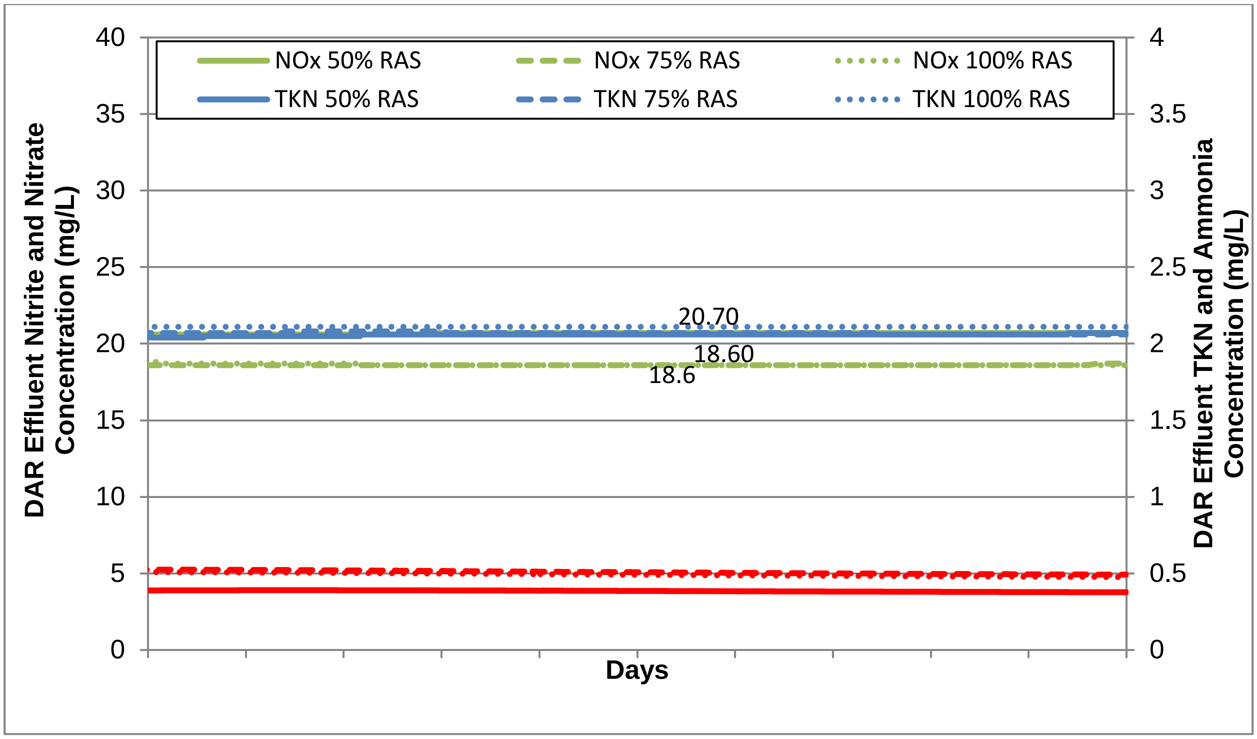

Figure 12
Alternative 3 Sensitivity Analysis: Variable DAR RAS Flow Rate

3.3.2 Modeling Results

The sensitivity analyses identified that converting the HPO reactors to operate as an aerated CAS system would degrade the CBOD removal of the first stage allowing a significant quantity of CBOD to pass into the DARs from the CAS basins. Table 9 shows that the model predicts CBOD concentrations from the CAS basins to range from 67 mg/L up to 103 mg/L depending on SRT. The ammonia concentration out of the first stage is also predicted to increase due to operation at a reduced DO.

Table 9
Alternative 3 Modeling Results Summary CAS Reactors

Average Annual Flow Rate (MGD)	Basins Online	SRT (days)	Avg. MLSS (mg/L)	AOR (lb O_2/day)	Avg. $cBOD_5$ (mg/L)	Avg. TSS (mg/L)	Avg. NO_x (mg/L)	Avg. NH_3 (mg/L)
57	2	0.51	990	8,050	103	10.4	0.05	34.4
62	2	0.51	1,090	9,200	103	10.4	0.05	34.4
67	2	0.50	1,180	11,350	96	10.5	0.11	33.7
72	2	0.60	1,510	14,670	92	10.8	0.09	33.7
77	2	0.65	1,850	17,800	85	11.0	0.09	33.3
82	3	0.70	1,460	22,220	74	11.1	0.07	32.6
87	3	0.70	1,590	25,740	67	11.3	0.07	32.0
92	3	0.70	1,690	27,060	67	11.6	0.07	32.0

Table 10 shows the results of HPO conversion to CAS on the effluent from the DARs. Because a low spike fraction was identified as optimal during the sensitivity analyses for this alternative, it was held to just 10% of influent flow. The simulations also used the static anoxic zone and 50% DAR RAS identified as optimal during the sensitivity analyses.

Table 10
Alternative 3 Modeling Results Summary DARs

Average Annual Flow Rate (MGD)	Spike Fraction	SRT (days)	Avg. MLSS (mg/L)	AOR (lb O_2/day)	Avg. $cBOD_5$/TSS (mg/L)	Avg. TKN (mg/L)	Avg. NO_X (mg/L)	Avg. NH_3 (mg/L)
57	0.1	11.5	3,300	79,200	10.1 / 10.9	2.28	18.0	0.75
62	0.1	10.5	3,400	86,500	10.7 / 11.4	2.33	18.5	0.75
67	0.1	10	3,310	91,900	11.0 / 11.5	2.42	19.3	1.09
72	0.1	11	3,380	97,400	11.3 / 12.0	2.33	19.7	0.68
77	0.1	10.5	3,310	101,000	11.5 / 12.1	2.43	20.3	0.77
82	0.1	11.5	3,180	104,800	11.4 / 12.1	2.38	21.5	0.72
87	0.1	12	3,140	109,000	11.6 / 12.4	2.41	22.2	0.72
92	0.1	12	3,350	115,500	12.0 / 13.2	2.49	22.3	0.72

Although the mixed liquor concentration (MLSS) was maintained at between 3140 mg/L and 3400 mg/L, the DAR SRT decreased as compared to the SRT achieved in Alternative 2. This is due to the much greater CBOD loading and therefore much greater quantity of biomass wasted from the DARs. Still the simulation indicates that the SRT is sufficient to give very effective nitrification and denitrification under the conditions predicted by the model.

The modeling results for Alternative 3 should be interpreted with caution as the model is actually indicating that the CBOD has not been metabolized in Stage 1 but much of it may actually be adsorbed to the biomass (some externally and some internally). The absorption mechanism is not well represented by GPS-X or most or other process models. Further, the adsorbed CBOD would be unavailable to the second stage (the DARs) in the overflow from the first stage clarifiers. Instead it would recycled back to the CAS with the return activated sludge (RAS) and wasted to the digesters as CAS waste activated sludge (WAS). Without the large CBOD influx from the CAS to the DARs the simulation results from Alternative 3 are unrealistic and should be interpreted according.

3.4 Alternative 3A – HPO Conversion to CAS with Denitrification in DARs and CAS Reactors

Alternative 3A was developed to more effectively exploit the excess volume available at the first stage basins than is possible with Alternative 3. It is a variant on Alternative 3 in that it includes conversion of the HPO basins to operate as conventional (aerated) activated sludge (CAS) while also operating the DARs to achieve some denitrification upstream of the denitrification filters. A key difference is that the CAS SRT is operated at 4 days to effectively reduce the CBOD in the first stage. An second major difference is that the first of the four zones in each CAS basin is operated without aeration. This converts 25% of the volume in each CAS basin to an anoxic zone for denitrification of the nitrate in the CAS RAS. Nitrification is achieved in the CAS basins at the 4 day SRT because of the relatively warm temperature at the site and because the WAS from the nitrifying biomass at the DARs is diverted to the CAS basins. This acts to supplement the CAS biomass with nitrifying microorganisms generated at the DARs in an approach known as bioaugmentation. As with Alternatives 2 and 3, the modeling for Alternative 3A was performed using January conditions as the “worst case”.

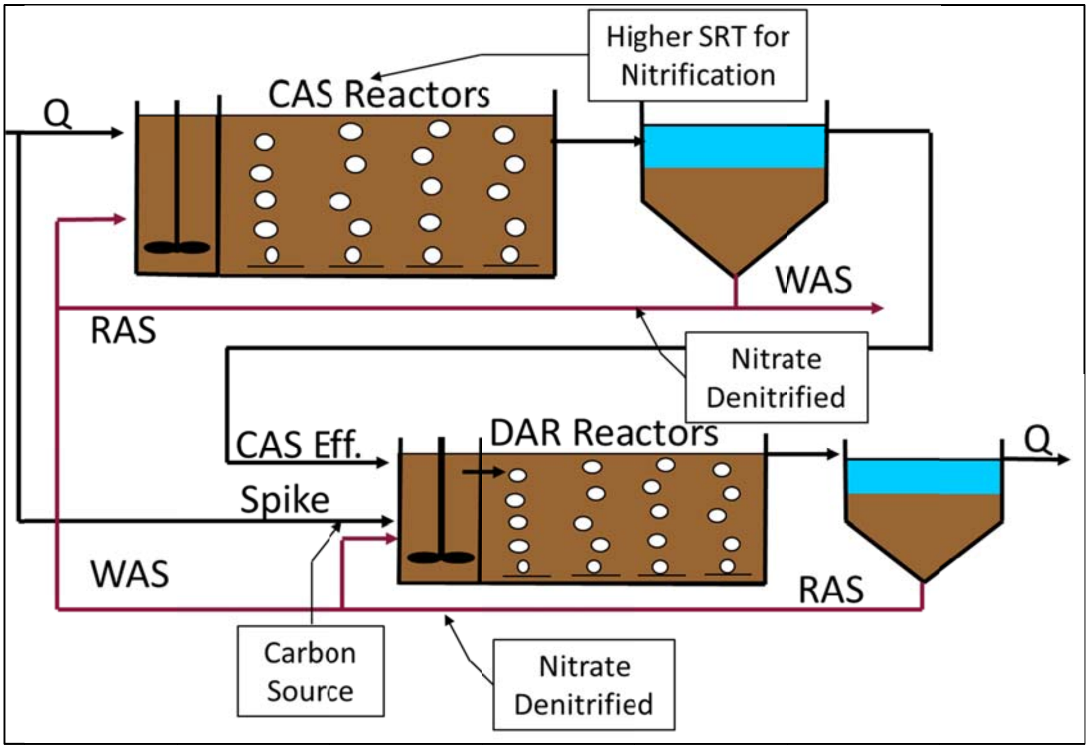

Figure 13
Alternative 3A: Schematic

3.4.2 Modeling Results

Modeling for Alternative 3A was performed at a CAS SRT of 4 days to give stable CBOD removal and nitrification. As shown in Table 11, the model predicts CBOD concentrations of approximately 9 mg/L from the CAS basins. Ammonia is fairly effectively removed to between 3 and 4 mg-N/L. Although denitrification of the nitrate in the RAS is effectively accomplished, 17 to 18 mg/L of nitrate remain in the CAS effluent. At flows above 77 MGD AADF it is no longer possible to achieve a 4 day SRT without exceeding the 3,500 mg/L MLSS limit so to apply this alternative to greater flows would require either additional CAS basins (up to a total of 9) or compensating increases to the MLSS concentration.

Table 11
Alternative 3A Modeling Results Summary CAS Reactors

Average Annual Flow Rate (MGD)	Basins Online	SRT (days)	Avg. MLSS (mg/L)	AOR (lb O_2/day)	Avg. $cBOD_5$ (mg/L)	Avg. TSS (mg/L)	Avg. NO_X (mg-N/L)	Avg. NH_3 (mg-N/L)
62	6	4	2,710	63,140	9.00	10.2	17.0	3.74
67	6	4	2,920	68,640	9.07	10.3	17.0	3.68
72	6	4	3,130	74,140	9.16	10.4	17.1	3.62
77	6	4	3,340	80,080	9.25	10.5	17.3	3.52
82	9	4	2,380	86,240	9.35	10.5	17.6	3.35

Model runs were not included for 57 MGD because the conversion to CAS would be done in the future when flows increase. Flow rates above 82 MGD were not included in the summary table because above 77 MGD AADF additional CAS basins would be required to operate using this scenario.

Table 12 shows the simulation results for the DARs operated under Alternative 3A. In this alternative the DARs use the 30% spike fraction for maximum carbon supply and MLSS is maintained at near 3500 mg/L to achieve maximum biomass for nitrification and denitrification without overloading the clarifiers. As a result of these operating conditions, the ammonia is predicted below 0.8 mg-N/L up to at least 82 MGD AADF. At 62 MGD AADF the effluent nitrate is predicted as 19.5 mg-N/L. This is a decrease of 12.8 mg-N/L (40%) as compared to the 32.3 mg-N/L of the current baseline operation and would allow a significant reduction in the quantity of methanol required as carbon source at the denitrification filters.

Table 12
Alternative 3A Modeling Results Summary DARs

Average Annual Flow Rate (MGD)	Spike Fraction	SRT (days)	Avg. MLSS (mg/L)	AOR (lb 0_2/day)	Avg. $cBOD_5$/TSS (mg/L)	Avg. TKN (mg/L)	Avg. NO_X (mg-N/L)	Avg. NH_3 (mg-N/L)
62	0.3	25.5	3,370	81,100	8.36 / 11.4	2.14	19.5	0.67
67	0.3	24.5	3,420	87,200	8.78 / 11.8	2.23	19.5	0.71
72	0.3	23.5	3,470	93,400	9.18 / 12.2	2.29	19.6	0.73
77	0.3	22	3,460	99,400	9.58 / 12.5	2.33	19.8	0.74
82	0.3	20	3,420	105,000	9.94 / 12.7	2.36	20.1	0.74

3.4.3 Economic Analysis

Although the City of Tampa will not convert the HPO reactors to CAS during the DAR aeration system replacement project, Tetra Tech performed a similar life cycle cost analysis for Alternative 3A as was performed for Alternative 2. . For this analysis, it was assumed that the HPO reactors would maintain current operation through 2018 when they would be converted to CAS. The plant cannot operate using CAS reactors through the permitted capacity of the plant. The modeling showed that the maximum capacity of the CAS reactors would be between 77 and 82 MGD. The economic analysis assumed the converted HPO reactors would maintain operation as CAS basins until influent flows are 90% of 77 MGD at which point they would be converted back to HPO basins which was projected to occur in 2028. For the DAR improvements, the same assumptions as Alternative 2 were used in this analysis.

Tetra Tech based the costs of converting the HPO reactors to CAS on the analysis performed by Greeley and Hansen summarized in the Technical Memorandum No. 2 Comparison of Alternative Processes issued in January 2012. The OPC for converting the HPO reactors to CAS reactors is $15.9 million not including the DAR aeration improvements. The OPC for converting the CAS reactors back to HPO reactors is $10.1 million which was assumed to be the same costs as required for the HPO rehabilitation determined for Alternative 2. The evaluation estimated the total 20 year cost at $131.6 million for this alternative. The detailed life cycle cost analysis is presented in Appendix B.

Based on current flows, pursuing Alternative 3A to denitrify in the CAS reactors and the DARs results in savings of approximately $1,380,000 in the first year of which $1,238,000 is methanol cost savings, $92,000 in aeration costs savings in the CAS reactors, and $50,000 is aeration costs savings in the DARs. The operational savings will pay for the HPO conversion to CAS and back to HPO in 18.9 years. If the CAS reactors do not need to be converted back to HPO reactors, the payback will be 11.5 years. If the City determines that flows will not exceed 77 MGD within the next 20 to 25 years, it would be cost effective to convert the HPO basins to CAS basins. In this scenario, the operational savings will pay for the conversion within a reasonable payback and would result in a lower overall life cycle cost. Given the uncertainty in this analysis, it is not recommended to convert the HPO basins to CAS basins if the City prefers to maintain the 96 MGD capacity rating.

4.0 Summary and Recommended Improvements Modeling

Under the existing operation at HFCAWTP all denitrification is achieved at the filters and requires costly methanol as an external carbon source. Because the facility was designed for a 96 MGD AADF capacity but is currently operating at 57 MGD AADF, there are unused HPO and DAR basins that may be temporarily repurposed to accomplish some nitrate removal without methanol. By denitrifying within the activated sludge process, aeration requirements there would also be decreased with resulting energy cost savings. This study was conducted to confirm the requirements for the aeration system replacement at the DARs.

A GPS-X model of the treatment process was calibrated to conservatively simulate the performance of the two stage activated sludge process at HFCAWTP particularly with respect to concentrations of the nitrogen species. Following calibration, three alternatives for future plant operation were modeled to predict their performance over a range of flows:

- Alternative 1 - Baseline Conditions
- Alternative 2 – Denitrification in DARs with Current HPO Operation
- Alternative 3 – HPO Conversion to CAS with Denitrification in DARs

Although the modeling results for Alternative 3 were judged to be unreliable, a related alternative was developed to better use the available capacity at the first stage basins by converting 25% of the volume to anoxic as the other 75% is converted to CAS.

- Alternative 3A - HPO Conversion to CAS with Denitrification in DARs and CAS Reactors

Results of simulations at the near future flow of 62 MGD AADF for the baseline operation as well as for the alternatives that provide denitrification upstream of the filters are shown in Tables 13 and 14. Both Alternative 2 and Alternative 3A provide improved nitrate removal and reduced aeration requirements at the DARs as compared to the current operation. Although Alternative 3A could be used up to an AADF of 77 MGD, Alternative 2 could provide at least some denitrification up to the plant's full 96 MGD rated capacity. Further, Alternative 2 may be operated in the current baseline conditions at any time simply by setting the aeration off period to zero hours in the adjustable aeration cycle.

Table 13
Modeled Effluent Nitrogen at 62 MGD AADF

Alternative	Effluent Ammonia (mg-N/L)	Effluent TKN (mg-N/L)	Effluent Nitrate (mg-N/L)
1 – Base: HPO + DAR w/o Denite	0.47	1.47	26.1
2 – HPO + DAR w/Denite	0.70	2.02	24.7
3A – CAS + DAR both w/Denite	0.67	2.14	19.5

Note: Alternative 1 results are on annual average basis, results for Alternatives 2 & 3A are monthly average for "worst case" month of January. For Alternative 1 the modeled January effluent nitrate-N concentration is 32.3 mg/L

Table 14
Estimated Energy Consumption at 62 MGD AADF

Alternative	1st Stage Aeration (kW)	2nd Stage Aeration (kW)	Total Aeration Energy (kW)
1 – Base: HPO + DAR w/o Denite	1,280	510	1,790
2 – HPO + DAR w/Denite	1,280	420	1,700
3A – CAS + DAR both w/Denite	930	510	1,440

Note: Alternative 1 results are on annual average basis, results for Alternatives 2 & 3A are monthly average for "worst case" month of January

The economic comparison of the alternatives is summarized in Table 15. Alternative 2 is projected to result in a savings of approximately $651,000 on methanol and energy in the first year of operation. The savings will in general increase as the AADF increases until denitrification performance begins to degrade as presented in Table 8 and/or the unit costs for methanol and energy increase faster than the rate of inflation. On a 20 year life cycle cost basis, Alternative 2 is estimated to save approximately $20 M as compared to continuing the current baseline operation (Alternative 1). Alternative 3A is projected to result in a savings of approximately $1,380,000 on methanol and energy in the first year of operation. On a 20 year life cycle cost basis Alternative 3A is estimated to save approximately $26.1 M as compared to continuing the current baseline operation (Alternative 1).

Table 15
Economic Comparison

Alternative	20yr Total Cost	1st Year MeOH Annual Savings	1st Year Energy Annual Savings
1 – Base: HPO + DAR w/o Denite	$157.7 M	$0	$0
2 – HPO + DAR w/Denite	$137.7 M	$587,000	$64,000
3A – CAS + DAR both w/Denite	$131.6 M	$1,238,000	$142,000

Alternative 2 would involve approximately $1.7 million in capital cost beyond the cost for HPO tank rehabilitation and baseline DAR aeration improvements. Alternative 3A would require an additional $15.9 M in capital cost to convert the HPO reactors to operate as CAS and that conversion would have to be reversed at a cost of approximately $10.1 M when AADF reached 77 MGD. Because it requires physical modifications to the HPO reactors, Alternative 3A is not as flexible as Alternative 2 which is controls based and so highly adaptable. Considering Alternative 3A is highly dependent on flow rate, if flow projections grow at a slow pace Alternative 3A would produce more long terms savings.

3.4 Recommendation

Because the 20 year savings projected for Alternative 2 ($20 M) is more than 75% of that projected to be achieved with Alternative 3A and yet Alternative 2 requires significantly less initial additional capital cost and has greater flexibility, Tetra Tech recommends that the City implement Alternative 2 at the HFCAWTP. Design of the replacement diffuser system for the DARs should provide for operation using on-off aeration in zones 1 through 5 but should also be adjustable to provide for continuous aeration across all zones to give the City the flexibility to operate under Alternative 1.

The diffuser design should also allow for efficient operation of the DARs in the event the City choses to implement Alternative 3A in the future. The modeling performed for Alternatives 2 and 3A includes a distribution of air demands per zone for the DARs. There is higher air demand at the head of the DARs compared to the end. For Alternative 2, the highest air demands will be in Zones 1 and 2 as presented in Table 16; however, for Alternative 3A, zones 1 and 2 are anoxic which pushes the highest air demands to Zones 3 and 4. These demands will be considered during the detailed design phase by providing the aeration header piping for a higher diffuser density in zones 1-4. In zones 3 and 4, the initial design will include place for the additional diffusers required if Alternative 3A is implemented; however, the diffusers will not be installed as part of this project.

Table 16
AOR per Zone for Alternatives 2 and 3A at 62 MGD AADF

Aeration Zone	AOR Alternative 2 (lb O_2/day)	AOR Alternative 3A (lb O_2/day)
1	12,400	0
2	12,400	0
3	10,800	32,000
4	9,800	26,400
5	8,000	12,800
6	10,200	9,900
Total	63,600	81,000

Detailed design of the diffuser system will also consider each zone's aeration requirement at the permitted capacity of 96 MGD and a DO of 2.0 mg/L as modeled in Alternative 1. The diffuser density will be designed with the greatest aeration efficiency at 57 to 62 MGD based on Alternative 2 AOR distributions. The detailed design phase will establish the minimum and maximum hourly airflows antricipated for each diffuser zone as well as the air demands on an average annual basis using on/off aeration at flows between 57 and 62 MGD.

END OF MEMORANDUM

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