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Project Summary

Survey and Evaluation of Fine Bubble Dome and Disc Diffuser Aeration Systems in North America

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A study of 19 North American municipal activated sludge plants equipped with either ceramic fine bubble dome or disc diffuser aeration systems was carried out to better define the oxygen transfer performance and operation and maintenance (O&M) requirements of these systems and the proper approaches to their design. Two of the plants were located in metropolitan Toronto, Ontario. The remaining 17 were located in the United States. The plants were selected on the bases of size and age of the system, location, and quality of available data from installation lists provided by the principal manufacturers of dome and disc diffuser equipment. All treat predominantly domestic wastes, though some have significant industrial flows as well.

Data on process design, influent and effluent wastewater characteristics, aeration power and air flow, and O&M experiences were requested from each plant. These were supplemented as needed by on-site investigations and interviews of plant personnel.

The results of this work indicate that, although the North American experience has not been as uniformly satisfactory as that of overseas users, ceramic fine bubble aeration technology can be successfully implemented here. Those plants that have avoided major design flaws and are operated conscientiously are performing quite well. Most of the problems encountered would require little money or time to correct. Better training of plant operators and improved design practices are urgently needed.

This Project Summary was developed by EPA's Water Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Interest remains high in the wastewater treatment industry in reducing power consumption and costs of energy-intensive treatment processes. Aeration for secondary and tertiary activated sludge treatment, often accounting for 50% or more of total plant energy consumption, continues to be a primary focus in the effort to reduce energy costs. Consequently, expanded use of reportedly more efficient aeration equipment has been experienced in North American plants in recent years. It was decided that enough new ceramic dome and disc fine bubble aeration systems had been installed and operated for a sufficient period by late 1982 to justify undertaking a domestic survey and evaluation of the technology.

The study's primary objectives were to assess the oxygen transfer performance and O&M history of ceramic dome and disc diffused aeration systems in North America and to enumerate and discuss the principal design factors affecting that performance. To allow comparison with an earlier foreign study of U.K. and European ceramic dome systems (Houck, D.H. and A.G. Boon. Survey and Evaluation of Fine Bubble Dome Diffuser Equipment. EPA-600/2-81-222, September 1981), the study approach and assessment methodology used were quite similar to that employed previously.

Characteristics of Aeration Systems

General

All 19 plants evaluated were equipped with either ceramic dome or disc diffusers supplied by one of the following manufacturers:

- *Envirex, Inc., Milwaukee, WI
- Gray Engineering Group, Ltd., Markham, Ontario, Canada
- Norton Company, Worcester, MA
- Sanitaire-Water Pollution Control Corp., Milwaukee, WI

The Gray and Norton systems featured 18-cm (7-in.) diameter dome diffusers of the type studied in the earlier U.K. survey. Envirex and Sanitaire manufacture disc diffusers. The Sanitaire disc diffuser is 22 cm (8.7 in.) in effective surface diameter; the Envirex disc is slightly larger. A list of the surveyed plants along with background information is given in Table 1.

Design and Operation

Aeration system design and operating data for the 19 plants visited are summarized in Table 2. Thirteen of the systems inspected were being operated in the plug flow mode. Another four were utilizing the step feed configuration, while one was using both the plug flow and step feed operating regimes in different tanks. One plant was employing the complete mix operating mode.

Several of the plants had aeration tanks described by their designers as complete mix that were clearly functioning in the plug flow mode (e.g., Riverside). Only three plants - West Bend, North Buffalo, and Coulton - were being operated in multiple-pass, plug flow configurations that resulted in length-to-width (L/W) ratios greater than 15. In contrast, over half of the U.K. and Dutch plants evaluated in the first survey project had aeration basin L/W ratios of more than 15. High L/W ratios create design problems in attempting to match oxygen demand with a diffuser layout of appropriate tapered density that will not yield zones of either under or overaeration.

Four of the 13 plants with plug flow basins were designed with uniform diffuser configurations; the other 9 were designed with tapered aeration. A uniform diffuser density substantially increases the difficulty of accurately matching oxygen demand with oxygen (air) supply in a plug flow aeration basin. Zones of over and/or underaeration are virtually impossible to avoid in such a situation. The problem becomes acute in multiple-pass plug flow basins with very long L/W ratios.

The recommended ranges of specific air flow rates for dome and disc diffusers are 0.24 to 0.94 L/sec (0.5 to 2.0 scfm) and 0.24 to 1.42 L/sec (0.5 to 3.0 scfm), respectively. Headloss across the media becomes very small at specific air flows less than the recommended lower limits, making it difficult to obtain uniform air distribution across the entire diffuser surface. Power costs generally become uneconomic if the recommended upper operating limits are exceeded for substantial periods because of decreased oxygen transfer efficiency and increased pressure on the blowers. The average air flow per diffuser was within the recommended ranges for 13 of the 17 plants with available air flow operating data. Four facilities were operating below their recommended ranges.

Diffuser density and air flow rates per diffuser varied widely, reflecting the lack of any standardized approach for designing dome and disc diffuser aeration systems in North America. Minimum power levels were generally much higher than those found in the U.K. plants. No problems with solids settling in the aeration tanks were reported by any of the plants evaluated.

Process Performance

Aeration system process performance data are presented in Table 3 for the 19 plants surveyed. Most of the plants were not designed for nitrification, though it was occurring in a number of them because they were underloaded or as a result of the mode of operation selected by plant personnel. Several plants featured two-stage activated sludge treatment. Most of the plants were operating well below design flows and were producing very high quality effluents.

Air flow varied from 22 to 112 m^3/kg total 5-day biochemical oxygen demand ($TBOD_5$) applied (350 to 1,800 ft^3/lb) in the North American plants but generally averaged less than that for the U.K. plants, even where nitrification was being practiced. In general, the non-nitrifying plants averaged less than 62 m^3 air supplied/kg $TBOD_5$ applied (1,000 ft^3/lb) unless there were problems with the aeration equipment. Nitrifying plants averaged much higher with the exception of the Village Creek plant, where the air flow data may have been questionable. Volumetric loadings in the North American plants were similar to those found in the United Kingdom, but food-to-microorganism (F/M) loadings were somewhat higher here, ranging from 0.03 to 0.59 kg $TBOD_5$/day/kg mixed liquor suspended solids (MLSS) vs. 0.05 to 0.45 in the United Kingdom. MLSS levels in the North American plants were usually less than 3,000 mg/L. Very little consistency was noted in basic process parameters among the North American plants, even between similar nitrifying or non-nitrifying plants.

Several disc-equipped plants had been originally designed and specified for the smaller dome diffusers. Subsequently, disc units were purchased and substituted for the domes on a one-to-one basis. At West Bend, this resulted in substantial overdesign of the aeration system such that it could not be operated efficiently at current loadings. Plant operators reported that they could not turn down air flow sufficiently to reduce the mixed liquor dissolved oxygen (DO) level below 6 to 9 mg/L and still maintain recommended minimum diffuser specific air flow rates.

Oxygen Transfer Performance

Method of Measuring Oxygen Transfer Performance

Considerable development work has been conducted in recent years for measuring oxygen transfer performance, including steady and non-steady state methods and off-gas analysis. For this project, since no direct oxygen transfer field measurements were made, oxygen transfer performance was estimated using empirically derived oxygen consumption values based on $TBOD_5$ removal and ammonia nitrogen (NH_4-N) oxidized. This oxygen mass balance technique was developed by Boon and Hoyland of the British Water Research

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Table 1. Characteristics of Surveyed Plants

Plant Location (Plant Name)	Aeration System Description	WW Flow (mgd)* Design	WW Flow (mgd)* Average**	Avg. % Removal $TBOD_5$	Avg. % Removal TSS
United States					
Coulton, CA	Partially nitrifying, concentric step feed basins with sludge reaeration, uniform diffuser layout, Gray domes	5.4	3.2	96	94
Greensboro, NC (North Buffalo)	Nitrifying, 2-pass plug flow basins following 1st-stage roughing biofilters, tapered diffuser layout, Envirex discs	16.0	12.0	95	95
Howard County, MD (Little Patuxent)	Nitrifying (summer), two-stage system, 2-pass step feed 1st stage basins, 1-pass plug flow 2nd-stage basins (operated in summer only), uniform diffuser layout both stages, Norton domes	15.0	8.9	97	97
Levittown, PA (Lower Bucks County)	Non-nitrifying, 1-pass plug flow basins, tapered diffuser layout, Norton domes	12.0	8.0	93	90
Rialto, CA	Nitrifying, 1-pass step feed basins, uniform diffuser layout, Gray domes	2.0	2.35	94	93
Riverside, CA	Partially nitrifying, 1-pass plug flow basins, tapered diffuser layout, Norton domes	13.8	9.0	98	98
West Bend, WI	Nitrifying, 5-pass plug flow basins following 1st-stage roughing biofilters, uniform diffuser layout, Sanitaire discs	9.0	4.5	98	98
Whittier, CA (Whittier Narrows)	Non-nitrifying, 1-pass plug flow basins, tapered diffuser layout, Sanitaire discs	15.0	12.5	90	90
Berlin, NH	Unknown nitrifying, 1-pass plug flow basins, tapered diffuser layout, Norton domes	2.2	1.7	94	94
Berlin, WI	Partially nitrifying, 1-pass step feed basins, uniform diffuser layout, Sanitaire discs	1.6	0.8	96	98
Fort Worth, TX (Village Creek)	Partially nitrifying, 1-pass plug flow basins, tapered diffuser layout, Norton domes	40.0	54.5	95	96
Lititz, PA	Nitrifying, two-stage system, 1-pass plug flow basins both stages, tapered diffuser layout both stages, Norton domes	3.5	0.9	98	98
Meriden, CT	Nitrifying, two-stage system, complete mix basins both stages, uniform diffuser layout both stages, Sanitaire discs	11.6	7.1	95	95
Montpelier, VT	Non-nitrifying, 1-pass plug flow basins, uniform diffuser layout, Sanitaire discs	3.97	1.5	92	95
Houston, TX (Park Ten Municipal Utilities Dist.)	Unknown nitrifying, 2-pass step feed basins, uniform diffuser layout, Norton domes	1.0	0.2	U	U
Ridgewood, NJ	Partially nitrifying, 1-pass plug flow basins, tapered diffuser layout, Gray domes	4.5	3.0	90	90
Seymour, WI	Nitrifying, concentric plug flow basins, uniform diffuser layout, Sanitaire discs	0.81	0.54	98	99
Canada					
Toronto, Ontario (Highland Creek)	Nitrifying, 1-pass plug flow basins, uniform diffuser layout, Norton domes	4.8	3.0	98	96
Toronto, Ontario (Humber-North plant)	Partially nitrifying, 1-pass plug flow basins, tapered diffuser layout,Norton domes	31.2	24.5	94	94

U = Unknown
* *1 mgd = 0.044 m^3/sec*
** *At time of plant visits from late-1982 to mid-1983*

Centre based on the work of Eckenfelder and O'Conner (*Biological Waste Treatment*. Pergammon Press, New York, NY, 1961) for use on the earlier survey. It has an estimated accuracy of ± 20% if reliable influent, effluent, and mixed liquor concentration data are available over a meaningful operating period along with dependable records of wastewater flow and air supply. The limits of accuracy become much broader if historical data are questionable or unreliable and/or if air flow control is poor.

The oxygen mass balance technique used in this study is represented by the following equation:

$$\text{Oygen consumed (lb/day)} \quad (1)$$

$$= R(BOD_S - BOD_e) + 4.3\,(N_S - N_e)$$

where:

R = units of oxygen consumed by heterotrophs per unit of $TBOD_5$ removed in lb/day and is described by the equation:

$$R = 0.75 + 0.05/(F/M) \quad (2)$$

with an assumed maximum R value of 1.5

BOD_s = reactor influent $TBOD_5$ lb/day
BOD_e = secondary effluent $TBOD_5$, lb/day
N_s = reactor influent NH_4-N, lb/day
N_e = reactor effluent NH_4-N, lb/day
F/M = food-to-microorganism loading, day^{-1}, based on MLSS under aeration

In contrast to the U.K. experience, no North American plants were equipped with lead-stage anoxic zones for promoting nitrate reduction and oxygen recovery using the denitrification process. Consequently, the third term of Boon and Hoyland's equation, which accounts for the oxygen credit (chemical oxygen released to the mixed liquor that lessens the amount of DO needed) derived from denitrification, was not needed in this study and is omitted from Equation 1.

An adiabatic compression equation, with corrections for equipment efficiencies, was used to estimate blower power consumption when only air flow data were available. Compressor efficiency was assumed at 70%, coupling efficiency at 95%, and motor efficiency at 92%. Factoring in these assumptions yields the following relationship:

$$\text{Wire Power Req'd (kW)} = 0.276\,Q \left[\left(\frac{P_a + P_1 + D_1 + SH}{P_i}\right)^{0.283} - 1\right] \qquad (3)$$

where:
Q = air flow, scfm
P_a = ambient air pressure, psi
P_1 = piping system headloss, psi
D_1 = diffuser headloss, psi
SH = static head above diffuser, psi
P_i = inlet pressure, psi

Diffuser stone headloss was assumed to be 0.3 psi, and total piping system headloss was assumed to be 0.3 psi. Ambient pressure was assumed to be 14.7 psi, and inlet pressure was taken as 14.6 psi.

Aeration Efficiency Estimates

Oxygen transfer performance is typically expressed in terms of aeration efficiency, which is defined as the mass transfer of oxygen per unit of line (or wire) power input. Mass balance estimates of oxygen consumption and either measured or estimated blower power consumption, as described in the previous section, were utilized to calculate estimated aeration efficiency values for each plant visited except Lititz and Park Ten as shown in Table 4.

A wide variation is evident in the estimated aeration efficiencies of the North American plants, ranging from 0.63 kg O_2/kWh (1.03 lb/wire hp-hr) for Humber to 2.52 kg O_2/kWh (4.15 lb/wire hp-hr) for Ridgewood. The average for the 17 plants for which aeration efficiencies could be calculated was 1.51 kg O_2/kWh (2.49 lb/wire hp-hr). This compares favorably with the average estimated aeration efficiency of 1.48 kg O_2/kWh (2.43 lb/wire hp-hr) for the 16 plants from the earlier survey for which adequate information was available to prepare estimates.

Of the above 17 North American plants, six were totally nitrifying at the time of the study (North Buffalo, Rialto, West Bend, Meriden, Seymour, and Highland Creek), six more were partially nitrifying (Coulton, Riverside, Village Creek, Ridgewood, Humber, and Berlin, WI), four were not nitrifying at all (Little Patuxent, Lower Bucks County, Whittier Narrows, and Montpelier), and no nitrogen data were available for one plant (Berlin, NH). The estimated average aeration efficiency was 1.59 kg O_2/kWh (2.62 lb/wire hp-hr) for the six nitrifying plants, 1.45 kg O_2/kWh (2.38 lb/wire hp-hr) for the six partially nitrifying plants, and 1.32 kg O_2/kWh (2.17 lb/wire hp-hr) for the four non-nitrifying plants.

The above results suggest that nitrifying systems are more energy efficient than non-nitrifying systems. A possible reason for their better oxygen transfer performance is their lower organic loading rates and longer sludge retention times (SRT's) contrasted with typical non-nitrifying systems. Longer SRT's are generally believed to promote higher alpha values and higher oxygen transfer rates in wastewater, thereby resulting in higher system aeration efficiencies provided the SRT's are not substantially longer than necessary to sustain nitrification.

Operation and Maintenance

Maintenance observations at the 19 plants surveyed are summarized in Table 5. Over one-half of these plants had significant problems with the diffuser systems at startup or within the first few years of operation. Two plants required complete replacement of the initially installed equipment. Plant operators on the job during initial installation reported that installing contractors were given little supervision and often did not fully check out the system after installation.

It was observed that some plant operators did not comply with the recommended minimum air flow rates given in literature provided by all the equipment suppliers. Four of the plants were operated at air flows below recommended minimums much of the time. In one case, the operator overloaded the aeration system in lieu of putting a second basin on stream, greatly exacerbating problems caused by failure of diffuser hardware. Installers at this same plant had overtightened much of the system's hardware, causing extensive dome hold-down bolt failure and air leakage.

About one-half of the plants were doing an adequate maintenance job. Several, such as Berlin (NH), Montpelier, and Seymour, were highly aware of the benefits of preventive maintenance and had set up and followed routine cleaning and checking schedules much like those observed in the United Kingdom. These plants reported excellent O&M experiences with their diffuser systems.

Conclusions

Unlike the generally favorable O&M performance observed overseas, the North American plants visited were more likely to have experienced significant problems with their fine bubble aeration systems. It appeared that many of the same design deficiencies noted in plants overseas have been repeated here. Problems with equipment had occurred in about one-half of the plants evaluated. Those plants that had experienced significant equipment problems tended also to exhibit relatively poor aeration efficiencies.

Overall, estimates of oxygen transfer performance for the North American plants were on a par with those estimated previously for the U.K. plants. In both surveys, however, several plants were producing aeration efficiencies well below the potential capabilities of ceramic diffusion technology. The sub-standard oxygen transfer performance of those U.K. plants exhibiting below normal aeration efficiencies could be tied in most cases to long tank L/W ratios, non-tapered diffuser configurations, and associated overaeration and wasted energy. On the other hand, the contributing factors for those North American plants with below-average aeration efficiencies appeared to be linked more closely to wastewater characteristics (i.e., greater contributions from

Table 2. *Aeration System Design and Operating Data*

Plant Name	Aeration Basin Dimensions: Length (ft)*	Width (ft)*	SWD (ft)*	Effect. Basin L/W	Diffuser Density (No./ft²)**	Diffuser Taper (%)	Air Flow per Unit Volume (cfm/1,000 ft³)†	Avg. Air Flow per Diffuser (cfm)††
Coulton: Unit I	124/174	8.25	10	126.5‡	0.30-0.25	Uniform	25.6-22.1	0.87
Unit II	153.5	14	14.4	32.9‡‡	0.41	Uniform	24.9-24.5	0 87
North Buffalo	260	20	14.5	26.0	0.23-0.14	33/26/22/19	22.7-13.2	1.43
Little Patuxent	185	30.25	15.3	12.2	0.39	Uniform	32.1	1.27
Lower Bucks County	200	30	15	6.7	0.28-0.16	64/36	23.3-13.3	1.25
Rialto	100	20	15	10.0	0.47	Uniform	19.3	0.62
Riverside	250	40	17.6	6.3	0.54-0.45	26/26/26/22	11.1-9.3	0.36
West Bend	113	19.8	18	28.5	0.17	Uniform	3.5	0.37
Whittier Narrows:								
Tank 1	300	30	14.4	10.0	0.26-0.15	39/38/23	23.3-14.2	1.14
Tanks 2 & 3	300	30	14.4	10.0	0.33-0.19	39/38/23	23.0-13.4	0.93
Berlin (NH)	100	25	15	4.0	0.27-0.15	45/32/23	7.2	0.71
Berlin (WI)	80	20	15	4.0	0.21	Uniform	10.4	0.74
Village Creek: Tanks 1,2, & 4	239	104	13.8	2.3	0.50-0.28	34/27/21/18	20.5-11.3	0.56
Lititz: Stage I	114	25	15	4.6	0.49-0.26	48/26/26	U	U
Stage II	139	30	15	4.6	0.41-0.22	48/26/26	U	U
Meriden: Stage I	100	56	18	5.4	0.10	Uniform	11.9	1 73
Montpelier	39	39	18	1.0	0.18	Uniform	3.6	0.37
Park Ten	92.3	30	14.5	6.2	0.31	Uniform	U	U
Ridgewood	116	24	15	4.8	0 26-0.14	33/29/19/19	10.7-6.0	0.62
Seymour	201	26	14.7	7.7	0.12	Uniform	5.4	0.64
Highland Creek	115	58	25	2.0	0.54	Uniform	7.2	0.34
Humber	246	58.3	24	4.2	0.56-0.28	47/29/24	30.2-15.1	1 29

U = Unknown
* 1 ft = 0.305 m
** 1 dome/ft² = 10.76 domes/m²
† 1 cfm/1,000 ft³ = 0.017 L/m³/sec
†† 1 cfm = 0.472 L/sec
‡ Based on six plug flow aeration sections of 174 ft each
‡‡ Based on three plug flow aeration sections of 153.5 ft each

industry with lower concomitant alpha values), equipment failure, and a higher incidence of diffuser sliming or fouling.

The principal conclusions of this study follow:

1 Estimates of system aeration efficiency varied widely for the visited plants but seemed to be linked to process configuration and loading conditions, wastewater characteristics, and/or O&M problems. Plants using higher rate processes seemed to have lower aeration efficiencies with one exception (Whittier Narrows) where O&M practices were rigorous and effective. Within the limits of the accuracy of the mass balance technique employed in this study, the estimated aeration efficiencies for the non-nitrifying activated sludge systems averaged 1.32 kg O_2/kWh (2.17 lb/wire hp-hr). The average estimated aeration efficiency of those plants where complete or a significant degree of nitrification was occurring was 1.52 kg O_2/kWh (2.50 lb/wire hp-hr). In general, it appears that the lower F/M and volumetric loadings and longer sludge ages necessary to sustain nitrification result in improved oxygen transfer performance and reduced rates of diffuser fouling.

2. Inadequate or inappropriate O&M procedures were found to be a principal contributor to less-than-optimum oxygen transfer performance and/or major equipment maintenance problems observed at some plants.

- For the most part, operators had been provided little or no literature or training for diffuser system operation, troubleshooting, or maintenance. Several of the plants visited had experienced major equipment failure, but the operators were not aware of this until it was pointed out to them. In general, plant maintenance mechanics did not know the correct procedures for checking, tightening, and replacing diffuser hardware, though several had developed effective procedures by trial and error.
- With only two exceptions, plant operators did not understand that fine bubble ceramic diffusers would probably require cleaning after 6 mo to 2 yr of operation, depending on the rate of diffuser media fouling and headloss buildup. Advance provisions for diffuser cleaning had been made only at the Village Creek plant (ultrasonic cleaning) and the Seymour plant (acid gas cleaning) and there was general ignorance of the time, manpower and equipment requirements, and costs associated with diffuser cleaning.

Table 3. *Aeration System Process Performance Data*

Plant Name	Average $TBOD_5$ (mg/L)			Average Volumetric Loading (lb $TBOD_5$/day/1,000 ft^3)*	Average MLSS (mg/L)	Average F/M Loading (kg $TBOD_5$/day/kg MLSS)	Average Air Flow
	Raw WW	Primary Eff.	Final Eff.				ft^3/lb $TBOD_5$ applied)†
Coulton	244	180	12	22.1	2,500	0.14	1,570
North Buffalo	200	120**	10	19.9	2,300	0.14	1,249
Little Patuxent	150	115	18††	21.7††	2,800††	0.24††	1,066††
Lower Bucks County	220	220 (est.)	15	40.8	2,800	0.23	647
Rialto	256	185	13	60.4	6,450	0.15	461
Riverside	160	80	5	8.5	2,700	0.05	1,799
West Bend	150	62**	8	5.8	600	0.15	866
Whittier Narrows	325	142	4	38.9	1,053	0.59	678
Berlin (NH)	195	60	12	7.6	1,750	0.07	576
Berlin (WI)	485	242	20	16.8	1,400	0.19	892
Village Creek	274	175	19	58.3	3,500	0.27	499
Lititz	177	119	5††	10.4††	U	U	U
Meriden	264	90	5††	17.6††	3,900††	0.07††	757††
Montpelier	128	66	10	7.5	2,000	0.12	349
Park Ten	U	--	10	U	U	U	U
Ridgewood	140	90	5	27.0	2,000	0.22	428
Seymour	360	--	4	10.5	5,800	0.03	711
Highland Creek	145	--	5	10.9	2,500	0.07	953
Humber	200	100	20	29.7	4,300	0.11	1,037

U = unavailable
* 1 lb $TBOD_5$/day/1,000 ft^3 = 0.016 kg/day/m^3
† 1 ft^3/lb $TBOD_5$ applied = 0.062 m^3/kg
** $TBOD_5$ of roughing biofilter effluent
†† Based on first-stage aeration only

- Plant operators were not aware of the relationship between process operation and aeration efficiency. Only a few were aware of the need to maintain minimum air flows, and several of the underloaded systems were being operated below recommended air flow rates per diffuser. None of the plant O&M manuals inspected provided any guidance for diffuser system maintenance or efficiency monitoring.

3. Poor aeration system performance and/or O&M problems were often attributable to design inadequacies or errors.

- Typical design errors included lack of aeration taper, poor inlet and outlet design, too many or too few diffusers, and lack of DO monitoring equipment. The excessive aeration tank L/W ratios common to many U.K. plants were not observed in this study.
- Little attention had been given to facilitating periodic maintenance at many of the plants studied. In most cases, draining of aeration tanks required the use of special pumping equipment.
- Most of the plants were not equipped with the monitors necessary to check aeration system performance. Specifically, few had separate power meters for aeration blowers and many had no means of measuring air flow to the aeration tanks. Provision of on-line DO monitors was uncommon, and those plants that had DO monitors often did not maintain them properly.
- Several plants had been designed for 28-cm (7-in.) dome diffusers but were equipped with the larger 22-cm (8.7-in.) disc diffusers because the latter were low bid, However, design engineers required that the same number of the larger diffusers be installed, resulting in oversizing of the aeration systems in these plants. Extensive research at Los Angeles County Sanitation Districts has verified that three 22-cm (8.7-in.) disc diffusers are equivalent to four 18-cm (7-in.) dome diffusers from an oxygen transfer standpoint.

4. Poor quality installation was a major cause of subsequent equipment problems. Often, critical hardware was over- or under-tightened, causing leakage and/or breakage. Manufacturer and/or design engineer supervision (most installations was minimal, an contractors often did not follow publishe guidelines. In some cases, the fragility (the plastic hardware contributed to th problem. The equipment supplied by th major manufacturers varied in sensitivit to installer error. However, when correctl installed, most of the equipment, with th exception of some gasket materials, wa relatively trouble free. Also, substanti: improvements in product quality hav been made in response to field problem and competitive pressures over the la: several years. Where problems hav been experienced, all of the princip suppliers have promptly honore equipment warranties, even wher complete system replacement has bee required.

5. Although diffuser sliming and foulin were only clearly indicated at four of th plants visited, zones of coarse bubblin were evident in several other plant Coarse bubbling may or may not b indicative of fouling, but it definitely has negative impact on oxygen transfe efficiency. Based on these limite observations, ceramic diffuser foulin appears to become more prevalent wi

Table 4. *Aeration System Oxygen Transfer Performance Data*

Plant Name	Avg. WW Flow* (mgd)†	Avg. Air Flow* (cfm)‡	Avg. Power Usage (kW)	How Power Usage Derived?	Data Quality	Calc. Field Aeration Efficiency (lb O_2/wire hp-hr)	(kg/kWh)
Coulton	3.2	5,400	149	calc.	poor	1.33	0.81
North Buffalo	12.0	10,420	386	meas.	good	1.36	0.83
Little Patuxent	8.9	5,500	154	meas.	fair	1 39	0.85
Lower Bucks County	8.0	6,600	223	meas.	fair	1 84	1.12
Rialto	2.35	1,160	50.2	calc.	poor	2.90	1.75
Riverside	9.0	7,500	203	meas.	fair	1.89	1.15
West Bend	4.5	1,400	61.1	meas.	good	1 85	1.13
Whittier Narrows	12.5	6,966	207	calc.	good	1.94	1.18
Berlin (NH)	1.7	340	8.3	meas.	fair	3.74	2.27
Berlin (WI)	0.8	1,000	31.4	meas.	good	1.91	1.16
Village Creek	54.8	27,720	812	calc.	fair	3.97	2.41
Lititz	0.9	U	U	--	poor	--	--
Meriden	7.1	2,800	102	meas.	fair	3.80	2.31
Montpelier	1.5	200	7.3	meas.	fair	3.49	2.12
Park Ten	0.2	U	U	--	poor	--	--
Ridgewood	3.0	670	19.6	meas.	short	4.15	2.52
Seymour	0.54	800	24.3	meas.	fair	3.22	1.96
Highland Creek	3.0	2,400	75	meas.	fair	2.57	1.56
Humber	24.5	14,710	730	meas.	good	1.03	0.63
					Average:	2.49	1.51

U = Unavailable
* At time of plant visits from late-1982 to mid-1983
† 1 mgd = 0.044 m^3/sec
‡ 1 cfm = 0.472 L/sec

Table 5. *Aeration System Maintenance Summary*

Plant Name	Year Started Up	Aeration System Startup Experience	Aeration System Operating Experience
Coulton	1981	Poor, entire system replaced	Excellent, no problems since replacement
North Buffalo	1982	OK, minor problems	General disc gasket failure in 1 yr
Little Patuxent	1980	Some breakage, leaking	Poor, frequent failure of plastic parts (particularly dome retainer bolts)
Lower Bucks County	1982	OK	Fair, slime growth from heat treatment recycle
Rialto	1981	OK	Excellent
Riverside	1982	OK	Excellent
West Bend	1980	OK	Excellent
Whittier Narrows	1981	OK	Some slime growth, cleaned periodically with hosing or gas injection, no mechanical problems
Berlin (NH)	1979	OK, some contractor error	OK, a few small leaks
Berlin (WI)	1981	OK	Some slime growth and possible plugging
Village Creek	1978	Poor, contractor error	Poor, significant leakage and periodic failures of plastic hardware
Lititz	1981	Poor, entire system replaced	Excellent, no problems since replacement
Meriden	1982	OK, some contractor error	Excellent
Montpelier	1981	OK	Excellent
Park Ten	1978	OK	Poor, system failed due to O&M error
Ridgewood	1983	OK, vendor's rep. installed	Some slime growth, cleaned periodically with hosing or acid brushing
Seymour	1982	OK	Fair, some plugging, in-situ gas cleaning system works well
Highland Creek	1968	OK, few problems	Excellent, no failures in 14 yr
Humber	1982	OK	No way to check system, possible failure

increasing process load, particularly at the influent end of plug flow reactors and the multiple feed points of step feed reactors. Where rapid diffuser fouling is encountered, a recently-developed, proprietary, in-situ, non-process interruptive cleaning technique using hydrochloric acid gas injection from the air side may permit aeration efficiency to be maintained at acceptable levels between more rigorous process-interruptive cleaning cycles.

6. Although the O&M performance data collected in this project are not as generally positive as those reported in the earlier U.K. study, it should be noted that several plants were visited where ceramic diffusers are performing quite well and have produced major energy cost savings. These plants are characterized by careful attention to correct installation and O&M of their diffuser systems. Where problems have been experienced, they could normally be diagnosed and corrected at reasonable cost. Basically, this stud verified that fine bubble ceramic diffusio technology can work well in Nort American plants and that improve design, installation, and O&M practice are the primary ingredients needed t maximize aeration performance an potential cost savings.

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The complete report, entitled "Survey and Evaluation of Fine Bubble Dome and Disc Diffuser Aeration Systems in North America," (Order No. PB 88-243 886/AS; Cost: $19.95, subject to change) will be available only from:
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