Fine Pore Aeration Systems Testing

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Fine Pore Diffusers

- Fine pore aeration systems are the most energy conserving alternative we have for the activated sludge process, and may other applications
- Well established technology and design principles
- Nevertheless, we have had many technology failures
- Proper utilization of the technology requires a commitment to maintenance
Outline

• Terminology
• Off-gas testing
• Materials testing
• Some conclusions
Terminology

• Efficiency
  – Standard oxygen transfer efficiency (SOTE) (percent oxygen transferred)
  – Standard oxygen transfer rate (SOTR) (mass transferred per unit time)
  – Standard aeration efficiency (SAE) (mass transferred per unit time per unit power)
Terminology Cont.

- SOTE - percent
- SOTR – lb O2/hr or kg O2/hr
- SAE – lb O2/hp-hr or kg O2/kW-hr
- All above at standard conditions (e.g. 20°C, clean water, etc.)
- OTE, OTR, AE – at process conditions
Standard and Process Conditions

• Correction formulas based upon driving force, temperature, barometric pressure, water quality, saturation concentration, etc
• Driving force and water quality the most significant
• Driving force = (DO_S – DO)/DO_S
• Water quality – alpha factor, 0 to 1
• Total correction can result in process water transfer of only 30 to 80% of clean water transfer
Off-Gas Testing

- Accepted as the best way to do process water testing of diffused aeration systems
- Used to the exclusion of almost all other methods for diffused systems
- Provides reliable indication of aeration efficiency, air flow distribution, wastewater flow splits among parallel aeration tanks, diffuser aging
- Reliable in underloaded, critically loaded and overloaded treatment plants
Off-Gas Technique

Hood to capture off-gas

Analyzer

Air
The Mathematics

$$OTE = \frac{\text{mass } O_2 \text{ in} - \text{mass } O_2 \text{ out}}{\text{mass } O_2 \text{ in}}$$

$$= \frac{G_i (M_o / M_i) \text{MR}_{o/i} - G_i (M_o / M_i) \text{MR}_{og/i}}{G_i (M_o / M_i) \text{MR}_{o/i}}$$

$$= \frac{\text{MR}_{o/i} - \text{MR}_{og/i}}{\text{MR}_{o/i}}$$

Use the ratio of oxygen to inerts to remove gas flow rate from the calculation.
Off-Gas Measurement

- Use a simple fuel cell to measure oxygen partial pressure
- Ambient air for calibration of mole ratio
- Remove moisture and CO\textsubscript{2} to simplify the procedure
- Measure off-gas and compare to ambient air
Measuring Air Flow Rate

• Not needed for OTE measurement
• Useful to create an average of a large basin
• Needed to calculate the oxygen uptake rate, or total mass transferred
• Measure discharge from hood by establishing a stable pressure under the hood
Off-Gas Analyzer

- Rotometer
- Manometers
- Fuel Cell
- Vacuum Cleaner
Analyzer in Action
Small Hoods
Large Hoods
Coarse Bubble Hoods

Testing in a turbulent spiral roll system requires a heavy hood and weights.

Sand Bags
Off-Gas Results

• Define aeration capacity
• Track aerator performance and “health”
• Better understand process conditions
• Define key process parameters for expansion
• Warranty Opportunities
Typical Results

Tank dewatered, diffusers brushed and hosed
A Tale of Two Tanks

High SRT (Nitrifying)

Low SRT (Non-Nitrifying)
Transfer Efficiency and Pressure Drop

In a small tank, one can test pressure drop, oxygen transfer efficiency and observe flow patterns.
Materials Testing in the Lab
Special Holders for Membranes
Decrease in Pressure Drop With Acid Cleaning

Pressure Drop (inches water column)

First HAC Addition
Second HAC Addition
Third HAC Addition

Pressure Drop

Time (minutes)
Field Pressure Drop Device
Typical Results Pressure Drop

![Graph showing pressure drop over elapsed time with diffusers cleaned at a specific point.]
Poor Flow Distribution
Evaluating Membrane Hardness and Strength
Durometer

Pin penetrates surface as a function of hardness
Small Test Frame

Force

Membrane “Dog Bone”

Displacement
Load Cell on Test Frame
Thickness

Pressure gage for repeatable measurements
Measuring Orifice Diameters

Pin inserts into an orifice a fixed distance as a function of its diameter
Change in Modulus
weakening with age

New

New

Old

Old

Membrane Number
Microscopic Examination
(Polyurethane Membrane)
Microscopic Examination
(Sintered Plastic)
Microscopic Examination
(EPDM Membrane)

New

Used
Silicone Membranes

From Wiehe and Libra (2004)
Conclusions

- It is easy to track fine pore aeration system performance with off-gas testing
- One or two days every few months gives a “health” report of the aeration system. Initial and periodic testing give good information for design
- Lab-scale testing for material properties and sources of fouling can predict failures or help you understand why membranes failed
- A small, but routine investment in testing is needed
- Must plan – cannot just decide to go out and test. Diffusers must be observed over time to detect changes in efficiency or properties