A DIGITAL CONTROL SYSTEM FOR
OPTIMAL OXYGEN TRANSFER
EFFICIENCY

APPENDIX E:
TECHNOLOGY TRANSFER
INFORMATION

Prepared For:

California Energy Commission
Public Interest Energy Research Program

Prepared By:
Southern California Edison
University of California, Los Angeles
Utility Technology Associates

January 2010
CEC-500-2009-076-APE
Documenting Improved Aeration Efficiency Using Off-gas Analyses

Shao-Yuan (Ben) Leu, Pan Jiang, Diego Rosso, Lory E. Larson, Roger Sung, Pramod Kulkarni, and Michael K. Stenstrom

UCLA Civil and Environmental Engineering
Introduction
- The modern wastewater treatment not only focus on effluent quality, but also energy consumption

Background
- Terminology & literature review
- Off-gas analysis

Methodology
- Real-time Off-gas Monitoring System
- Field Experiments

Results and Discussion
Introduction

- Activated Sludge Process
  - Aeration needs energy (45~75% of the total)
  - Fine-pore diffusers to increase aeration efficiency
Terminology

- **MCRT** = Mean Cell Retention Time
- **OTR** = Oxygen Transfer Rate (mass $O_2$/time)
- **OTE** = Oxygen Transfer Efficiency (%)
  \[(OTE = \frac{OTR}{Total\ Oxygen\ Supplied})\]
- **SOTE** = OTE at standard conditions
  \[(20^\circ C,\ 0\ mg/l\ DO,\ 1\ atm,\ 0\ salinity,\ etc.)\]
- **Alpha factor** ($\alpha$) – water quality estimate
  \[(k_La_{\text{Process\ water}} / k_La_{\text{Clean\ water}})\]
Diffuser Fouling

- Fouled pore
- Diffuser cleaning test
Diffuser cleaning test

Fouled

Cleaned
Rosso et al., 2005
SOTE = f(MCRT, Q_{air})
Diffuser fouling can be quantified by the reduction of SOTE

<24 mo.
Rosso et al., 2005
SOTE = f(MCRT, Q_{air})
Diffuser fouling can be quantified by the reduction of SOTE
Diffuser Cleaning
Off-gas Test

- Off-gas test is an easy way to measure SOTE
  - Accurate
  - Real-time
- Developed by Redmon et al., 1983
- Basic theory
  \[
  OTE = \frac{O_2\text{in} - O_2\text{out}}{O_2\text{in}}
  \]
- ASCE, 1997
Off-gas Test

- Hood
- O₂ purity meter
- Air capture pipe
- To vacuum cleaner
Instrument sizes

Original instrument

Field-scale 1.0

Field-scale 2.0
Project Outcomes

- An easy-to-operate off-gas monitoring system
  - Automatic analyzer
  - Real-time measurement
  - Small Hood
  - Maintains accuracy
Field Experiment

- 10 MGD treatment plant
- Aeration uses fine-pore diffusers
- Grab sample and off-gas test 1/hr for 24 hrs
Field Results

- Recorded Signals

![Graph showing oxygen molar fraction and oxygen transfer to wastewater over time from 11:00 AM to 5:00 PM.](image-url)
Results

- Comparison 24-hour data
  - OTE vs. Air flow rate
  - CCOD vs. Alpha
- The results confirmed our former long-term observations

The results confirmed our former long-term observations.
24-hour Test – SOTE\textsubscript{off-gas}/SOTE\textsubscript{clean water}

REFERENCE - CLEAN WATER

AFTER CLEANING

BEFORE CLEANING

Labels are $\alpha$SOTE (%).
Shaded areas are 85% confidence intervals.
Long Term – Cleaning Frequency

Reference: Rosso et al., 2005
24 hrs – Plant Operation

- Real-time monitoring system provides useful information for plant operation

![Graph showing oxygen transfer and requirements over 24 hours with low loading periods and oxygen required to remove pollutants.]
Conclusions

- 24-hour experiments confirmed our previous observations
- Energy-saving potential quantified
- Our database as a valuable tool for accurate design and specification of aeration systems and plant operation
- Current work on feasibility of blower upgrade
Acknowledgements

- California Energy Commission
- Southern California Edison
- UCLA research group
Questions?

Shao-Yuan (Ben) Leu
syleu@ucla.edu

Prof. Michael K. Stenstrom
stenstro@seas.ucla.edu