Control Strategy Integration

Implementation at Kalamazoo Water Reclamation Plant
Outline

• Operations & Process Control Cooperation

• Control Strategy Implementation Examples

• Aeration System Control Strategy
Operations & Process Control
Cooperation
Operations & Process Control Cooperation

**Benefits**

- Better Operations Sequences
- Increased Understanding
- Accurate Information
Value of Accurate Process Information

Composition

- Timely Decisions
- Effectiveness of Treatment
- Loading to Process
Value of Accurate Process Information

- **Level**
  - Flow-pacing

- **Pressure**
  - Smooth Treatment Transitions

- **Temperature**
  - Automate Processes

- **Flow**
Control Strategy Implementation Examples
Automated Influent Pumping

- Full Flow Range by Empirical Testing
- Negative Deadband Benefits
Secondary Loading Integration

**COD/BOD Analyzer**

- Correlate Demand
- BOD & COD Flexibility
Secondary Phosphorus Loading Integration

**PE Soluble Phosphorus Analyzer**

- **Know Phosphorus Loading Now**
- **Timing Ferric Dosing Better**
- **Potential to Know Nutrient Balance Now**
Secondary Phosphorus Removal Integration

**ML Soluble Phosphorus Analyzer**
- Treatment Effectiveness
- Timing

**TE Soluble Phosphorus Analyzer**
- Know Actual Discharge
- Correlate
Secondary Ammonia Removal Integration

**ML Ammonia Analyzer**
- Treatment Effectiveness

**TE Ammonia Analyzer**
- Daily Maximums Permit

**TE Nitrate Analyzer**
- Degree of nitrification
**Disinfection**

- *Flow-paced Hypochlorite Dosing*

- *Creative Flow Programming*

- *Residual Chlorine Analyzers*
Tertiary Dechlorination Integration

**Sodium Bisulfite Dechlorination**

- **Flow-paced Bisulfite Dosing**

- **Dosing Flexibility**

- **Travel Time Coordination**
Thickened Solids Pumping

- Pump Assignment Flexibility
- Phosphorus Nutrient Balance
- Co-Mingled Sludge Ratio
Aeration System
Control Strategy
Upgrade to BNR in 2011

- Fine bubble diffusers
- Anaerobic, anoxic, aerobic zones
- Replaced 2 of four 2500 HP blowers with two 1350 HP blowers.

- Cascade control already embedded in the control strategy.
- Opportunity to learn new control strategies and understand better what we already we using.
Control Challenges

Cascade Control Challenges

- DO
- Air Flow
- System Pressure
- Blower Amperage
- Aeration Valves
- Guide Vanes
Understand Timing

- Controller driving the set point

  at least 3X faster than receiving set point
Basic Aeration Control

DO Analyzer Operator Selected for Control (choice of 2)

DO Controller Operator Selected Set Point

Operator Selection for Average

Operator Selection of Redundant Transmitters

Motor Amps

Air Header
DO and Air Flow Control

DO Analyzer Operator Selected for Control (choice of 2)

DO Controller Operator Selected Set Point

PV

Out

OV

PV

Out

PV

Out

PV

Out

PV

Out

Motor Amps

Operator Selection for Average

Operator Selection of Redundant Transmitters

Operator Input

DO Probe

AE

FT

FV

Blower

Air Header
DO Control Loop

**DO Controllers**

- PV
- SP - mg/L
- OUT

requests air needed

**Air Flow Controllers**

- PV
- SP - cms
- OUT

sets air flow set point

↑ air valves

changes system pressure
DO Controller Optimization

• **Select Probe for Control Option** - select front or back DO probe to be used to control output to air flow controller.

• **Output Rate of Change** - set gain, reset time, and control zone for speed of output to air flow controller.

• **Output Range** - set high/low air flow range to avoid controller wind up or wind down.

• **Timing** - set output ranges based on demand.
Air Flow Controller
Air Flow Controller Optimization

- **Output Rate of Change** - set gain, reset time, and control zone for speed of output to aeration control valve.

- **Output Range** - set high/low valve travel range to avoid controller wind up or wind down.

- **Timing** - set output ranges based on demand.
Aeration Pressure Control

DO Analyzer Operator Selected for Control (choice of 2)

DO Controller Operator Selected Set Point

PV AIC

Out

AT

PV

Out

DO Probe AE

FT

FV

Air Header

Blower

Motor Amps

PV

Out

ZIC

SP

Out

Operator Selection for Average

PV

DOPC

SP

Out

Operator Selection of Redundant Transmitters

PV

PIC

SP

Out

Operator Input
Aeration System Pressure Sensor
Pressure Sensor Influences

- Aeration valve position
- Number of blowers in service
- Blower guide vane positions
Aeration Pressure Control

- DO Analyzer Operator Selected for Control (choice of 2)
- DO Controller Operator Selected Set Point
- Operator Selection for Average
- Operator Selection of Redundant Transmitters
- Motor Amps

Diagram shows connections between various components such as DO Probe, Aeration Pressure Control, Operator Input, DOPC, PIC, ZIC, and Blower.
Pressure Control Loop

Average DO Calculation

PV
SP - mg/L
OUT

System Pressure Controller

PV
SP - kpa
OUT

Requests pressure needed to increase or decrease air.
Sets pressure set point within selected pressure range.
DO Average Calculation Options

- Calculate an average DO based on front end DO probes.
- Option given to select front end or back end DO probe for the average calculation.
- Flexibility for supervisor to influence blower air output.
# Average DO Control Flexibility

## Individual Aeration Tanks

<table>
<thead>
<tr>
<th></th>
<th>Front DO</th>
<th>Back DO</th>
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<tbody>
<tr>
<td><strong>mg/L</strong></td>
<td><strong>mg/L</strong></td>
<td></td>
</tr>
<tr>
<td>Aer 3</td>
<td>3.6</td>
<td>4.5</td>
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<tr>
<td>Aer 4</td>
<td>3.6</td>
<td>4.0</td>
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<tr>
<td><strong>Aer 5</strong></td>
<td><strong>3.8</strong></td>
<td><strong>2.0</strong></td>
</tr>
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<td>Aer 6</td>
<td>3.9</td>
<td><strong>2.2</strong></td>
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<tr>
<td>Aer 7</td>
<td>3.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Aer 8</td>
<td>3.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Aer 9</td>
<td>3.1</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>Avg</strong></td>
<td><strong>3.5</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SP</strong></td>
<td><strong>3.2</strong></td>
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</tbody>
</table>

## Average DO Calculation

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<td><strong>Avg SP</strong></td>
<td>3.2</td>
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**Output to Pressure Controller**
- **decrease**
- **increase**
**Pressure Control Optimization**

- **Adjustable Average DO Calculation** – creates pressure setpoint within adjustable 5 kpa range.

- **Output Rate of Change**

- **Output Range**

- **Pressure Relief Feature** – reduces pressure setpoint if high alarm reached.

- **Timing** - set output ranges based on **demand**. Supervisor able to make manual changes to increase rate if needed.
Blower Amperage Control

System Pressure Controller

PV
SP - kpa
OUT

Requests blower amperage needed to increase or decrease blower air output.

Blower Amperage Controller

PV
SP - amps
OUT

Sets amperage set point within selected range.
Output sent to guide vanes.
2500 HP Blowers
1350 HP Blowers
Basic Aeration Control
Guide Vane Control

Amperage Controller

PV

SP - amps

OUT

Requests guide vane change to increase or decrease air.

Blower Guide Vane Controller

SP - % open

Adjusts guide vanes according to manufacturer specifications.
Blower Guide Vane Control Challenges

- Two different blower sizes.
- Two different guide vane controls.
- Work with manufacturer to optimize performance.
Aeration Control Configuration
Thanks for Listening.

Questions?