Mixing Guidelines for Biological Nutrient Removal

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A brief History
Submersible Mixers: 50+ Years

• Submersible mixers invented by Flygt and first commercial versions in 1958!

• Photograph of set up with flow guide for ice prevention.
1975

Manure mixing trial
Overwhelming results
Sparked
• renewed interest
• Re-dedicated effort
What we discovered

The advantage with submersible mixers:

- **Freedom of Positioning**
1977

Submersible mixer
re-introduced to the world

Four sizes from 1.5 to 20 HP
1992
BNR Market
Compact Mixers
Mixer and Agitator Product Line

Submersible compact mixers
- 4610-20
- 4630-40
- 4650-60
- 4670-80
Compact HE
- 4650 LSPM

Submersible midsize
- 4530
- 4460 7.5kW

Submersible low-speed mixers
- 4410
- 4430
- 4460

Jet mixers
- JT4710
- JT4715
- JT4720
- JT4730
- JT4735

Hydro ejectors
- JP4710
- JP4715
- JP4720

Ultra-low-head pumps
- PP4630-PP4680

Top entry agitators
- 4850
- 4860
- 4870

Installation Equip.
Common Mixing Duties

- **Blending soluble liquids**
  - Batch mixing
  - Through-flow mixing

- **Suspension**
  - Re-suspending solids off bottom or drawing down solids from surface crust
  - Keeping solids in a homogeneous suspension

- **Circulation**
  - Providing flow as in Oxidation Ditches

- **Dispersion**
  - Breaking up and distributing droplets, bubbles or particles
• BNR – blending, solids distribution, suspension
Mixing goals for BNR:

1. Prevent settling
2. Prevent short-circuiting
3. Force good biological contact
4. Minimize energy use
Repeat distance $L_R$ or the required number of mixers

$L_R = 2.5 \ W - D$ \hspace{1cm} (SM/JM)

$L_R = 1.5 \ (up \ to \ 2) \ W$ \hspace{1cm} (TEA)
Multiple impellers in a tall narrow tank

Rule of thumb:

Add an impeller each time $H/T$ passes a multiple of 1.25
Flygt Mixer Positioning
Creating Mixing and Bulk Flow

Many flows, one source
- Inflow
- Outflow, better known as primary flow
- Jet: initial jet and entrained flow
- Bulk Flow
Flygt Mixer Positioning
Creating Mixing and Bulk Flow

Intensive mixing zone

Bulk Flow
Flygt Mixer Positioning
Mixer Jet

• Jet drives both primary flow and bulk flow
• Jet brings the surrounding liquid into motion
  • The surrounding low-velocity liquid is entrained
• Majority of the mixing is not in the prop-area
• Intensive mixing happens along the jet border
Flygt Mixer Positioning for a bulk flow loop

1. Determine an efficient bulk flow loop
   • Smooth jet deflection for low losses
   • Because mixing happens along the jet border, the longer the jet-path, the more mixing takes place
   • This often means the mixers are located in corners

2. Locate the mixer(s) so they are directed along the streamlines of the loop

3. Aim the jet to steer clear of obstacles
Submersible Mixer Positioning

1. Determine an efficient bulk flow loop
Submersible Mixer Positioning

2. Locate the mixer along the streamline of the loop
Submersible Mixer Positioning

3. Long jet path

Large fluid entrainment and bulk flow
Submersible Mixer Positioning
4. Smooth jet deflection

Smooth jet deflection:
Yields low hydraulic losses
Submersible Mixer Positioning
Long jet path & smooth deflection
Submersible Mixer Positioning

5. Away from obstacles

- Pipes, Pillars ...

- Bends, Aerators ...
Submersible Mixer Positioning
Optimal positioning

Rectangular tanks

Circular tanks

Tanks viewed from top
Submersible Mixer Positioning
Rectangular tanks: Single mixer

Aim for 1/4 width for maximum bulk flow

View from top
Madison, WI Nine Springs WWTP

Anaerobic Selector Basin Dimensions

33’ Long
30’ wide
17’ deep
Typical Conventional Activated Sludge Process

Influent → Pre-Treatment → Primary Clarifier → Primary Effluent → Aeration → Mixed Liquor → Secondary Clarifier → Disinfection → Effluent

Return Activated Sludge → Waste Sludge
Grit Removal
Fine screens

Added to the plant
Enabled lower mixing energy
Anaerobic Zones
Mixer sizing

1996:
- 7.5 HP - 1.15 ft/sec

2012:
- 2.5 HP - 0.7 ft/sec
- 4 HP - 0.85 ft/sec
Mixing energy
Cut in half
7.5 HP vs 2.5 & 4 HP

Before

After

7.5 HP

2.5 HP

7.5 HP

2.5 HP

Before

Before

Madison Metropolitan Sewerage District
View from top
Most efficient mixer today:
large diameter, slow speed
Questions?