Laser for Open Channel Flow Metering

Pump Station Flow Monitoring

Presented by:
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Presentation Objective

Keep your Toolbox equipped with Flow Metering Solutions

• Introduce a New Technology for Open Channel Flow Measurement

• Review a Time Tested Approach for Pump Station Flow Monitoring
Outline

• Overview of Open Channel Flow Measurement (OCM) Technologies

• Intro Latest Technology for OCM

• Review Pump Station Flow Monitoring
Open Channel Flow Measurement (OCM)

- **Empirical Formula** – Manning Equation
- **Primary Device** – Flumes & Weirs and Eq’s
  - Both used Level Sensors: Floats, Bubblers, Pressure Transducers - all Contacting Ultrasonic *(Non-Contacting)*
- **Area Velocity**
  - Velocity & Depth Sensors
    - Better Accuracy
    - Portable, Easy to Deploy
Continuous Wave Doppler (CWD)
[the economical workhorse]
Pulsed Doppler (PD)
[higher accuracy, perf, & reliability at higher cost]
Contact Sensors

The drawbacks of Contacting Sensor technologies are:

• Reliability
  – Blinding (loss of reading)
  – Silting (accuracy uncertainty)
  – Failure (damage / exposure)

• Maintenance / Cleaning
  – (cost)

• Small pipes (feasibility)
  – Sensor caused obstruction in flow
  – Debris, hydraulic issues
These drawbacks associated with contacting sensors have driven technology to provide “Non-Contacting” measurement solutions
Non-Contact vs Contact...Why?

• **Maintenance**
  – Blinding, Silting, Debris
  – Far fewer visits required by non-contacting solutions
  – Frequency & Costs (~$500 per site visit)

• **Safety**
  – Cannot get flushed down a sewer pipe if you are not in the sewer.

• **Large Pipe**
  – Difficult Installations
    • Flow Depths greater than 3 ft (tough for CWD)
    • Velocity over 3ft/second (equip wash-out)

• **Small pipes** – <24” Low level flow measurement
  – Shallow water depths with high velocities

• **Confined Space Entry for Maintenance**
  – Permits / Traffic Control / Manpower
Non-Contact Radar

- Very Intelligent approach. Sensor above the sewage.
- Non-contact Level Measurement (Ultrasonic)
- Non-contact **Surface** Velocity Measurement (Radar)

**Advantages**
- Minimal maintenance
- Above water installation
- Low level flow measurement

**Limitations**
- Single Point, Surface Velocity Measurement does not yield velocity measurement representative of cross section
- Dead band in ultrasonic level measurement
- Required velocity profiling

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**Only read velocity at the surface!**
Area Velocity

• “Contacting” Meters
  – Continuous Wave Doppler (CWD)
  – Pulsed Doppler (PD)

• “Non-Contact” Meters
  – Radar
  – Laser
    • Latest Advancement in Velocity Measurement Technology
Introducing Isco’s Non-Contact Solution

LaserFlow

- Non Contact Laser Velocity measurement
- Non Contact Ultrasonic Level Measurement
Basic Operation Sketch—Velocity Measurement

Δf = 2 V cosθ / λ
V = λ * Δf / (2 cosθ)

where:
Δf = Doppler frequency shift
V = Water velocity
θ = 45 degrees
λ = Laser wavelength

V = λ * Δf / (2 cosθ)

Below Surface
Ultrasonic Level Measurement

Single Point Velocity Method

Laser Velocity Measurement

Ultrasonic Level Measurement
Theory of Operation

Below the surface

Return Doppler Signal Light

5000 Spectral Velocity Readings
Off-axis reflected energy is weak and misdirected.
On-axis reflected energy is directed back to the sensor. However, the unfocused energy is very weak.
On-axis and focused reflected energy is directed back to the sensor with much intensity.
The frequency shift between the transmitted indicates the flow direction. The magnitude of the shift indicates the velocity.
Ultrasonic Level Sensor

- Range 0 – 10 feet
- 45° Deflector Plate
- 10° Beam Angle

- Virtual Zero Dead band
- Ultrasonic dead band is exceeded by the time the signal reaches the bottom of the LaserFlow.
Design Concept

• Peak to average relationship
  – Peak velocity is typically below the surface of the water at lower depths
  – Moves away from the water surface at higher depths

• Turbidity and TSS – Total Suspended Solids
  – Minimum 15 PPM

• Balance
  – 1/2” to 6” Below the surface in typical raw wastewater applications
Ultrasonic Level Measurement

Laser Velocity Measurement

Single Point Velocity Method

Single point Velocity Method
Multidepth Velocity Method
Ultrasonic Level Measurement
Laser Velocity Measurement
Multipoint Velocity Method

Multipoint Velocity Method
Multipoint - Multidepth Velocity Method
When do you use single point velocity measurement?

- Uniform and consistent flow
- Battery Life is a concern
- Rapid Data Rate – 1 minute
When do you use Multipoint velocity measurement?

- Non-Uniform Flow
- AC Power
- Longer Reading intervals
Submerged Condition

- Measurement during Submerged condition
  - **TIENet™** CW area velocity sensor
    - Proven technology
    - Not a point velocity measurement
    - More accurate during surcharged conditions

- Measurement can start on different conditions
  - Variable Rate Data Storage
    - Laser Level
    - Laser Velocity
    - Laser Temperature
    - CW Level
    - CW Velocity

- Laser cone design prevents water from reaching the laser window
TIENet™ Area velocity sensor connected to LaserFlow sensor

Single cable from LaserFlow sensor

Area Velocity (laser)

Level (USLS)
- Laser velocity
- Ultrasonic Level (USLS)
Submerged Condition Begins

Area Velocity
(Laser → CWD)

Level
(USLS + pressure transducer)
CWD sensor reading velocity

Area Velocity (CWD)

Pressure Sensor reading depth

Level (pressure transducer)
TIENet Area Velocity sensor with a longer cable 1,10, 23M
Product Specifications

- Level range accuracy
  - 0.02 ft at 1 ft level change or less
- Velocity range
  - +/-15 ft/sec
- Minimum depth for velocity
  - 0.5”
- Focus range of Laser
  - 0.5” - 6” below the surface at 15 NTU /PPM
- Turbidity / TSS range
  - 15 - 1,000 NTU/PPM
- Operating temperature
  - Up to 140°F
- Battery Life @ 15 minute readings with single point, unidirectional setup
  - 12 Weeks
Product Specifications
Housing Materials

- Corrosion resistant ABS plastic
- IP 68
- Anodized aluminum
- Stainless steel hardware
- Ultrasonic Sensor
  - Kynar (corrosion resistant)
Installation Requirements

- Laser can be installed facing in the upstream or downstream pipe.
- Center the bracket over the flow stream.
Installation Requirements

- Install the LaserFlow sensor in the middle of the pipe, parallel to the water surface.
- Use the “Laser On” function to see where the beam hits.
Permanent Mount
Permanent Mount

• Wall mount bracket
  – Vertical adjustment
    • X – axis adjustment
    • or roll
Permanent Wall Mount
Street Level Installation Tool

Street level installation alignment tabs
Level installation
Locking handle
Street Level Tool

Max length 23 ft
Facing into the flow
Facing away from the flow
Temporary application

- Spreader bar
Stability of Mounting hardware
How well does LaserFlow Technology Perform?

Examples of Actual Performance

• Accuracy
• Repeatability
Single Point Velocity Method

Within 0.5%
Omaha LaserFlow vs ADFM

Difference = 0.36%
SAWPA comparison vs. OCSD reference Magmeter
LaserFlow Applications

• **Collection System Monitoring**
  – Billing
  – Inflow and Infiltration

• **WWTP**
  – Permit Reporting:
    • Raw Influent
    • Final Effluent
  – In plant pipes and channels

• **Hydraulic Modeling**
  – Highly Accurate & Reliable Data Sets

• **Industrial Discharge monitoring**
  – Harsh Chemicals and/or Environments

• **Storm water**
  – Large debris
Summary

• **LaserFlow**
  – Advanced Laser Velocity Measurement
  – **Multipoint** Subsurface Velocity Measurement
  – The only non-contact flow measurement system that reads **below the surface**
  – Both precise and accurate
  – Easy to install and maintain
  – Excellent Submerged flow measurement option
  – **Flexible Platforms**
    • 2100 (Portable Battery Operated)
    • Signature (Permanent – Process Meter)
Oh, by the way...
...did you know?

• CWD, PD, and LaserFlow sensors can be used to measure and log Water Temperature?
  – Help indicate source or distinguish between inflow or infiltration

• Some sensors can provide continuous logging of velocity reading quality indicators.
Lift Station Monitoring
4501
Application

Any application where “fixed” speed pumps are moving fluid from point A to point B.

&

Where the pumps are activated when specific volume thresholds are met in the source!
Purpose and Applications for Lift Station Monitoring

- Wastewater collection system studies
  - Dry and wet weather flow conditions
  - Inflow and infiltration studies (I&I)
- Capacity monitoring
- Future planning
- Billing measurement
- Lift station performance studies
- Proactive maintenance programs
Lift Station Monitor Operation

• **Benefits:**
  • Accurately measure within 1%
    • Influent flow
    • Pumping rates for each pump
    • Volume processed by the station

• **Diagnose**
  • Abnormal pump station performance
  • Maintenance issues
  • Power issues
Lift Station Meter Setup

• Station information.
  • Wet well volumes calculated using
    • Wet well dimensions
    • Pump operation levels
    • Minimum requirement!!!
  • Rated pump capacity
  • Pump draw down test data
    • Single pump operation
    • Combination pump operation

• Station meter programming methods
  • Volume method
  • Rated pump capacity alone
    • Rated pump capacity used when the station parameters cannot be obtained
    • Pump capacity not learned nor updated... fixed!
    • Not as accurate!
Principle of Operation

- Wet well fills and empties
  - Monitors pump ON / OFF intervals
    - OFF = FILL
    - ON = EMPTY
  - The volume and time intervals are used

- Algorithms applied to calculate
  - Flow into and out of lift station
  - Pumping rate of each pump
3 methods of calculation

1 - Extrapolation Method

Calculation method in the 4501.
3 methods of calculation
2 - Averaging Method
3 methods of calculation

3 - Trending Method

Method used by the PC software

Pumplink uses the 5 preceding events and the 5 following events to calculate and determine “trend”
Summary Report

**PUMP OPERATION**

<table>
<thead>
<tr>
<th>Combination Average Outflow</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(1 &amp; 2)</th>
<th>(1 &amp; 3)</th>
<th>(2 &amp; 3)</th>
<th>(1, 2 &amp; 3)</th>
<th>Total volume that went</th>
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<tbody>
<tr>
<td>(713.5)</td>
<td>(777.9)</td>
<td>(0)</td>
<td>(1110)</td>
<td>(0)</td>
<td>(0)</td>
<td>(0)</td>
<td>(0)</td>
<td>(0)</td>
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**OVERALL OPERATION**

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<th>Inputs</th>
<th>Total Time</th>
<th>Occurrences</th>
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</thead>
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<tr>
<td>Input #1</td>
<td>828:13:43</td>
<td>9906</td>
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<td>Input #2</td>
<td>828:20:13</td>
<td>10338</td>
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<td>Input #3</td>
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<td>Input #4</td>
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<td>0</td>
</tr>
<tr>
<td>Input #5</td>
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<td>0</td>
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<td>Input #6</td>
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<td>1692</td>
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<td>Input #7</td>
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<td>Power failure</td>
<td>96:59:22</td>
<td>36</td>
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</table>

**Station Settings**

- Phone number: 9,1 (814) 372-4826
- Influent is Above highest level
- Volume Between levels 5 & 6: 100.0 Gallons
- Volume Between levels 4 & 5: 100.0 Gallons
- Pumps 2 and 3: Yes
- Pumps 1, 2, and 3: Yes

**Station Layout**

- When level goes up: Nothing
- When level goes down: Nothing
- Action at level 6: Nothing
- Action at level 5: Nothing
- Action at level 4: Any pump starts
- Action at level 3: Any pump starts
- Action at level 2: Any pump starts
- Action at level 1: Nothing

General station statistics from day of installation
### Monthly Report

**Inflow data**
- MIN
- MAX
- AVG

**Pump data**
- # of starts
- Run time
- Avg rate

**Day by day summary**

### SPECIAL EVENTS
- Description: Power Failure
- Day: 8
- Qty: 2
- Duration: 00:00:04

- Description: Power Failure
- Day: 9
- Qty: 1
- Duration: 00:00:02

### COMBinations of Pumps
- Pumps
- Average
- Occurrences
- Timer

<table>
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<th>Pumps</th>
<th>Average</th>
<th>Occurrences</th>
<th>Timer</th>
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<td>710.2</td>
<td>277</td>
<td>22:38</td>
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<td>2</td>
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<td>277</td>
<td>22:54</td>
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<tr>
<td>1, 2 &amp; 3</td>
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Daily Report

Daily summary broken into 30 minute intervals
### Event Report

**EVENT REPORT For: 03 / 28 / 07**

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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Level</th>
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<th>Outflow</th>
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<td>O</td>
<td>X</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>2</td>
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<td>1.682</td>
</tr>
</tbody>
</table>

**Detail of event by event activity – the primary tool for station performance analysis!**
Lift Station Monitoring Recap

• Collection system studies
  • Dry weather analysis
  • Wet weather analysis
  • System planning/modeling

• Station monitoring
  • Maintenance needs
  • Pump performance
  • Diagnostics – station performance
QUESTIONS

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