Application of Process Instrumentation in Water & Wastewater Treatment Plants

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Siemens AG
Major challenges of treatment plant operators

1. Growing urban population
2. Increase in demand for higher quality water
3. Implementing the ever growing stringent regulations for the quality of water
4. Aging infrastructure, “do more with less”
5. Building new or upgrading existing infrastructure is expensive
6. Energy costs are increasing

Instrumentation solutions helps meet these challenges by improving plant efficiency, increasing operational safety, and reducing the operating cost
Applications of Process Instruments in municipal water and wastewater treatment plants

Agenda:

1. Municipal water & wastewater treatment process schematics and applications

2. Key applications and benefits of instruments in wastewater treatment:
   - wastewater collection system
   - Wastewater treatment processes
   - bio-solids treatment processes

3. Key applications and benefits of instruments in drinking water treatment:
   - raw water intake, back wash water, booster station management
   - bulk water metering
   - remote data acquisition

4. Benefits of integrating field instruments in plant control network
   - Case study – City of Vernon, BC
Typical wastewater treatment process schematic and applications of instruments
Typical water treatment process schematic and applications of instruments
Key applications & benefits in wastewater treatment plant – collection system

Wastewater collection system consists of:
- sewer networks
- pumping stations (or lift stations)
- storm water retention tanks

Key Applications:
- CSO monitoring (legal requirement)
- date, time and duration of overflow events to be recorded
- recording of volume throughput in storm event
- lift station control and management
- storm water retention tank management
Key applications & benefits in wastewater treatment plant – collection system

Challenges in collection system:
- narrow wet well
- confined measurement environment
- foam, Scum, and other floating matters
- wall build-up
- noisy electrical environment
- submersion of the wet well
- aggressive atmosphere

Customer requirements:
- regulation compliance
- operation safety and security
- intelligent alarms
- remote data communication
- pump automation
- reduced operation & maintenance costs
Combined sewer overflow (CSO) logging – collection system

Dry Weather Flow Measurement:

- Flow Measurement at the CSO & data logging for date, time, duration and volume throughput in storm event
- with Echomax Transducer and EnviroRanger (Sitrans LUC 500)
- with Area x Velocity: OCM III or EnviroRanger (Sitrans LUC 500)
Lift (pump) station control – collection system

Pump Control in lift stations using ultrasonic level technology:

- non contacting level measurement
- multiple pump control routines:
  - fixed/alternate
  - duty assist/duty backup
- safety start:
  - pump start delay – pump power
  - resumption delay
- pump maintenance reduction:
  - pump service ratio algorithm
  - pump data acquisition
- wet well maintenance reduction:
  - variable pump set point
  - pump run on
- pumped volume totalization (patented algorithm)

Wet wells with ultrasonic transducers mounted
Some challenges and innovative solutions in pump controls – collection systems

- Every sewer network and lift station experiences:
  - false alarms due to narrow wells and obstructions
  - flooding and submergence
- software development in instrument design overcome these traditional problems
Challenges and innovative solutions for sewer network or lift station flooding – collection systems

Flooding of the collection system can be detected using a submergence shield with the transducer.

**Without a Submergence Shield?**
1. Submerged Condition
2. Transducer cannot measure
3. Loss of echo (LOE)
4. Stop Pumps

**With a Submergence Shield**
1. Level HOLD at 100% during submergence
2. Submergence Condition detected and recognized by the Intelligent Transceiver
3. No LOE
4. Pumps still running during Submergence
Lift station management with Sitrans LUC 500 – collection system

1. Lift station management includes:
   - pump control + monitoring digital and analogue I/O’s + event logging + remote data communication with central SCADA + report on exception of the events etc.

2. Economy pumping to reduce pumping costs
   - modify pump control according to time of day / peak cost period
   - storm by-pass

3. Monitor Trends (patented algorithm)
   - pumped performance & efficiency
   - infiltration analysis
Lift (pumping) station and CSO monitoring improvements with Sitrans LUC 500

**Improve operational efficiency**
- varying start / stop levels to reduce fat build up and extend cleaning intervals
- scum removal
- pumped volume totalising for regulatory returns
- use of intelligent alarms to reduce callouts

**Reduce maintenance costs**
- regular pump exercising
- pump efficiency alarms

**Improve compliance with environmental legislation**
- start on rapid rise to reduce spillages
- starts pumping before high level reached
- pumps early while the flow can still be beaten.
- will reduce incidence of CSO discharge
- automatic logging of overflow events

**Reduce energy costs**
- energy Saving features
- 20 % saving achieved

**Reduce capital investment**
- direct Modbus connection between pump controller and outstation (Looks like its cost neutral)
- LUC 500 Influence on asset management
Cobourg, ON pumping station case study: cost savings – collection system

**INPUTS**
- XRS-5
- HiHi/LoLo Floats
- PUMP # 1 On/Off Status Failure
- PUMP # 2 On/Off Status Failure
- PUMP # 3 On/Off Status Failure
- Pump Reset

**CONTROL STRATEGY**
- Duty Assist

**OUTPUTS**
- Station Alarm
- PUMP # 1 Start/Stop
- PUMP # 2 Start/Stop
- PUMP # 3 Start/Stop

**MAIN PLANT WIDE AREA NETWORK**
- Telemetry
- Pump # 1 and 2 Starts, Running Hours, Total Pumped Volume
Cobourg, ON pumping station case study: cost savings – collection system

Benefits (30% savings) of integrating EnviroRanger Sitrans LUC 500 connected over a dial-up modem with main plant HMI

- Time savings by information gathering (no site visit)
  - LUC 500 controls the pump routines, calculates pump run hours and starts
  - it totalizes pumped volume and displays the pumped volume and instantaneous flow rate from magflow input

- Improves station efficiency and reduce maintenance cost
  - customer gets all the station data at his HMI without PLC/RTU, informs customer on process or instrument upsets

![Graph showing pumped volume and fill rate over time](image)
Open channel flow measurement – collection systems and in wastewater treatment plant

Open channel flow measurement is employed to monitor:
1. Uses weir or flume as primary device
2. plant inlet & outlet flows
3. flows between the structures
4. for CSO monitoring

Case study: CRD Victoria, BC
- more than 50 outfall stations for monitoring & logging discharge flows
- built-in RTU to transmit flow data to central SCADA system over Modbus
- capital costs and operating costs savings, and improves monitoring efficiency
Differential level measurement

- As the screen gets plugged, the differential level up-stream & down-stream of the screen increases
- At a set differential the level alarm is generated to start the rack for the cleaning of the screen
- An additional alarm can be initiated indicating that the rake is activated but the differential is not decreasing
- 2 analogue outputs provided for differential level and either upstream or downstream level
Miscellaneous level and volume measurement – water & wastewater treatment plants

Ultrasonic technologies are applied for 95% of the level & open channel flow measurement applications

Liquids – small vessels
- Drinking Water
- Waste Water
- Sludge
- Chemicals

Solids – low range:
- Sand
- Grits
- Screen refusal
- Sludge hoppers
- Gas holder
Radar level measuring applications – wastewater treatment plant

**Electromagnetic wave**
- Similar to radio, cellular, television

**Travels at speed of light**
- Time to target and return is directly related to distance

**No carrier medium needed**

**Virtually unaffected by:**
- Temperature
- Vapor
- Pressure / Vacuum
- Dust

Receiver Sampling

Amplitude

500,000 pulses per sec.
FMCW Radar Level Measurement Principle

Electromagnetic wave

Frequency Modulated Continuous Wave

Continuous transmit sweep over frequency range

Differential frequency determines the distance

Echo Profile Process Intelligence

FMCW

Time

Frequency

24GHz

25GHz

L

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Transmit

Receive
SITRANS LR for Liquids – Difficult Application?

SITRANS LR200 (5.8GHz) may be better for:

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<th>Foam</th>
<th>Deposit</th>
<th>Turbulence</th>
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6 GHz has a longer wavelength than 25 GHz.
- Longer waves penetrate foam easier
- Deposit has smaller effect with longer waves
- Longer waves reflect better from turbulent surfaces
Level measurement in anaerobic digesters – bio-solids treatment process

Pulse radar technology is used to measure total level of foam and liquid in the digester:

- methane gas and other gases present in digester tank makes ultrasonic technology unreliable
- differential pressure transmitters used cannot detect foam and tank can overflow
- sliding wave-guide antenna (patented design) solves both the above problems
- customer saves maintenance costs and increases safety of process and security of the personnel
Electromagnetic flowmeters are extensively applied in collection systems & treatment plants:

Typical applications:
- to monitor pumping station effluent discharge
- to control the RAS flow into aeration tank
- to monitor & control the chemical dosing
- to monitor the sludge flow in bio-solids treatment

Region of PEEL, ON pumping station discharge

Chlorine dosing monitoring
Challenges in flow measurement – collection systems and wastewater treatment plants

Challenges:

- Installation constraints
  - not enough straight runs
  - accidental submergence
- High solids content makes conventional electro magnetic flow meters to fail
- Regulations asking to annually verify the flow meter accuracy

Solutions:

- Modular design of electromagnetic flowmeters
- AC type electro magnetic flowmeters handle liquids up to 70% solids content
- In-situ annual verification is possible without taking the meter out from the process

Insufficient straight pipe

Pump discharge

In-situ annual verification
- No interruption of flow
- Full installation test including the transmitter, sensor and cabling
- Fully automated verification in less than 15 minutes
- prints report that is acceptable to MOE
Key applications & benefits in water treatment plant

Raw water intake:
In-flow measurement with clamp-on or electro magnetic type flow meters:
- Electro magnetic flowmeters are widely applied, independent of the type of pipe, tolerates tighter conditions
- Clamp-on meters are mounted outside the pipe so do not need to cut the pipes, portable meters, economical when pipe sizes are large, growing technology

Raw water in-take pump control using ultrasonic level technology

Clamp-on flow meters are installed up to 9 meter size pipes

Electro magnetic flowmeter in Region of Halton, ON on finished water lines

SCADA screen shot shows 6 raw water intake pumps are controlled at Peterborough, ON wtp using ultrasonic level technology
Solids level measurement using radar technology – water treatment plants

- Activated Carbon silo 20M at Edmonton wtp, AB
- Activated carbon silo – pulse radar technology
- Lime silo 12M at Saint John wtp, NB
- Lime silo 12M shot from inside showing the built-up near the pulse radar horn antenna
Head loss measurement for filters – water treatment plant

Differential pressure transmitters are employed to measure the head loss across the filters to take the filters for back-wash at the set head loss

Series of 30 filters at R L Clerk wtp, Toronto, ON

Details of differential pressure transmitter connections

Head loss monitored by differential pressure transmitters
Bulk water metering – drinking water distribution

- Recent trend in water supply utilities is to accurately monitor and bill the consumers.
- City of Toronto, Montreal, Saint Johns, Halifax, etc. are installing thousands of meters to monitor the consumption and track the night flows for leakage detection.
- They follow the OIML standards to specify the meters.

Terminology old ISO 4064
Mechanical meters

Terminology OIML R49
EN14154, MI001 Water meters

Note: Q3 is typically 1.6 x Qn
Battery powered electro magnetic flow meter as a billing meter – advantage over mechanical meters

- Long term stability
- No mechanical wear
- Obstruction-free meter
- NO maintenance
- Lower total cost of ownership (TCO)
- Separate mounted electronics
- Data logger and self test
Remote data acquisition – water & wastewater treatment plants

Flexible IO and communications
Data Logger
Web application
Alarming - E-Mail/Text messaging

FTP server/Sync Manager
OPC
GPRS and Ethernet remote communications

Auto Detection of IO
Remote data acquisition – water & wastewater treatment plants

- Flexible I/O inputs – Auto Addressing
- Digital – Input and Outputs
- Analogue - ±10V and 0/4-20 mA
- Temperature - Thermocouple or RTD
- Modbus
- Auto Detection of I/O

Ethernet
GSM/PSTN
GPRS

4-20mA inputs
Digital inputs
Temperature
+/-10V inputs
Modbus
Remote data acquisition – water & wastewater treatment plants

Data Logging
- CSV file format
- Data Logging and Event/Alarm review
- No special software
- IT ready
- Up to 2 Gig memory
- Removable CF Card
Case study “benefits of integrating field instruments in plant control network” – City of Vernon wtp, BC

Project information:
1. Owner is Greater Vernon water Utility
2. Consultants are AEKWL consortium of Associated Engineers and Kerr Wood Leidal
3. Completed in June 2006 provides 40 Million Liters (11MG) per day to 35000 consumers in the Greater Vernon area

Project Challenges:
- To have cost effectiveness and efficiency in design and build phase
- Achieve safe operation of the plant
- Choose one Network for electrical, control and instrumentation

Solution:
Profibus instrumentation saves money at a new water treatment plant:
- It is the only network that can handle instrumentation & electrical control in one Network, saving enormous engineering and design time
- It works well in multi vendor applications
- It saves cabling and cable laying costs
- Easy installation and commissioning of the plant
- Only one vendor to deal with
- Robust communication
Applications of profibus instruments – City of Vernon wtp, BC

Raw water intake pumps

Raw water intake flow measurement by clamp-on meters

Hypochlorite tank level monitoring - Ultrasonic technology

Process water flow measurement – Electro magnetic flowmeters
Applications of profibus instruments – City of Vernon wtp, BC

Clear well level by differential pressure

PLC in panels and profibus cabling

SCADA screen shot showing all the devices on profibus network
Any Questions?
THANKS