2018 Conference

michigan water environment association mwea the water quality people

American Water Works Association Michigan Section

Magnetic Flow Meters
Diagnostics and Smart Meter Verification

Dan Elze
Flow and Density Specialist
Emerson Process Automation

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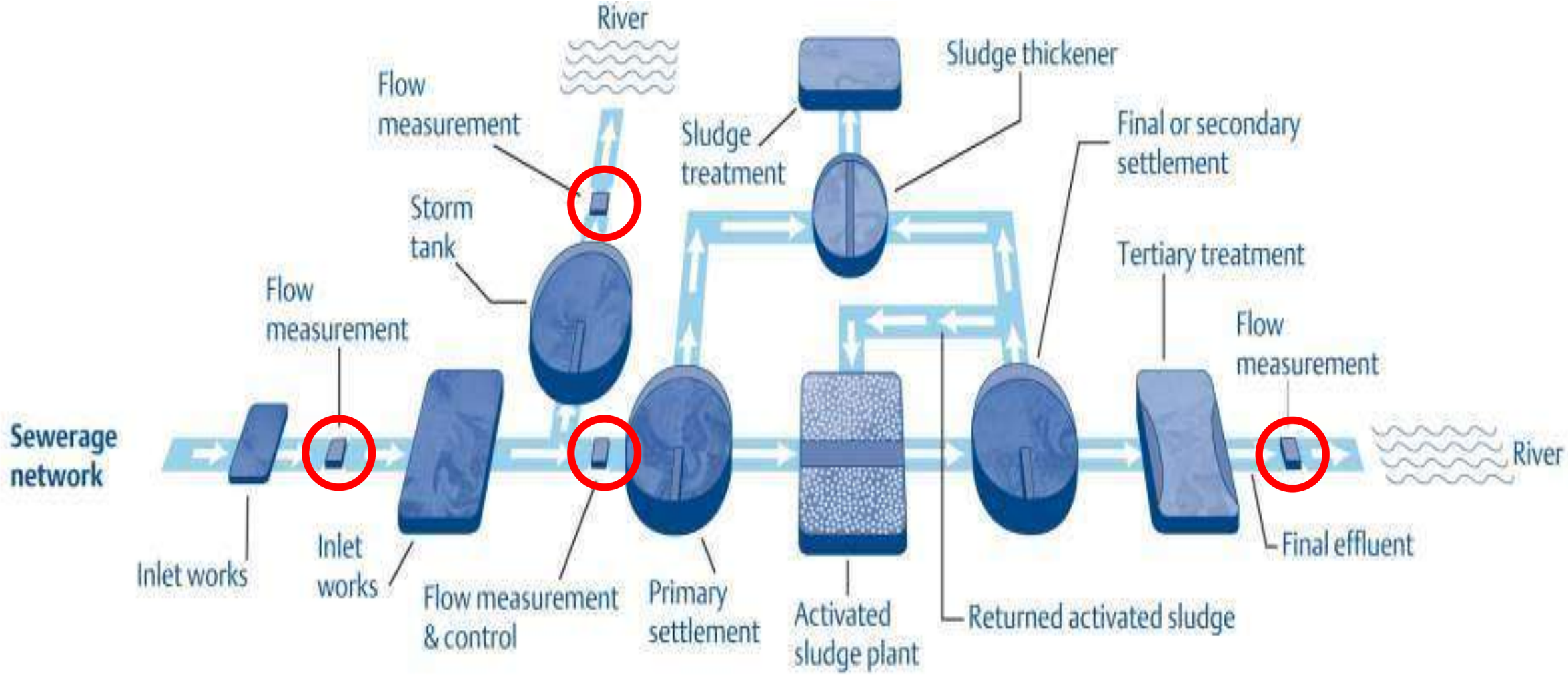
Magnetic Flow Meters

Typical Measurement Points



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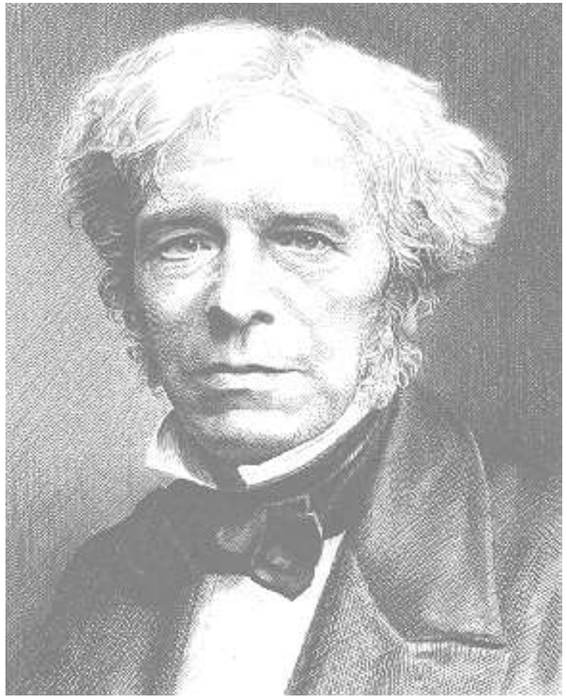
Magnetic Flow Meter Theory of Operation
Faraday's Law of Electromagnetic Induction

- A voltage will be induced in a conductor moving in a magnetic field (E)
- The magnitude of that induced voltage is proportional
  - to the velocity of the conductor (V)
  - to the length of the conductor (D)
  - to the strength of the magnetic field (B)

E = k * B * D * V



Michael Faraday (1791 - 1867)

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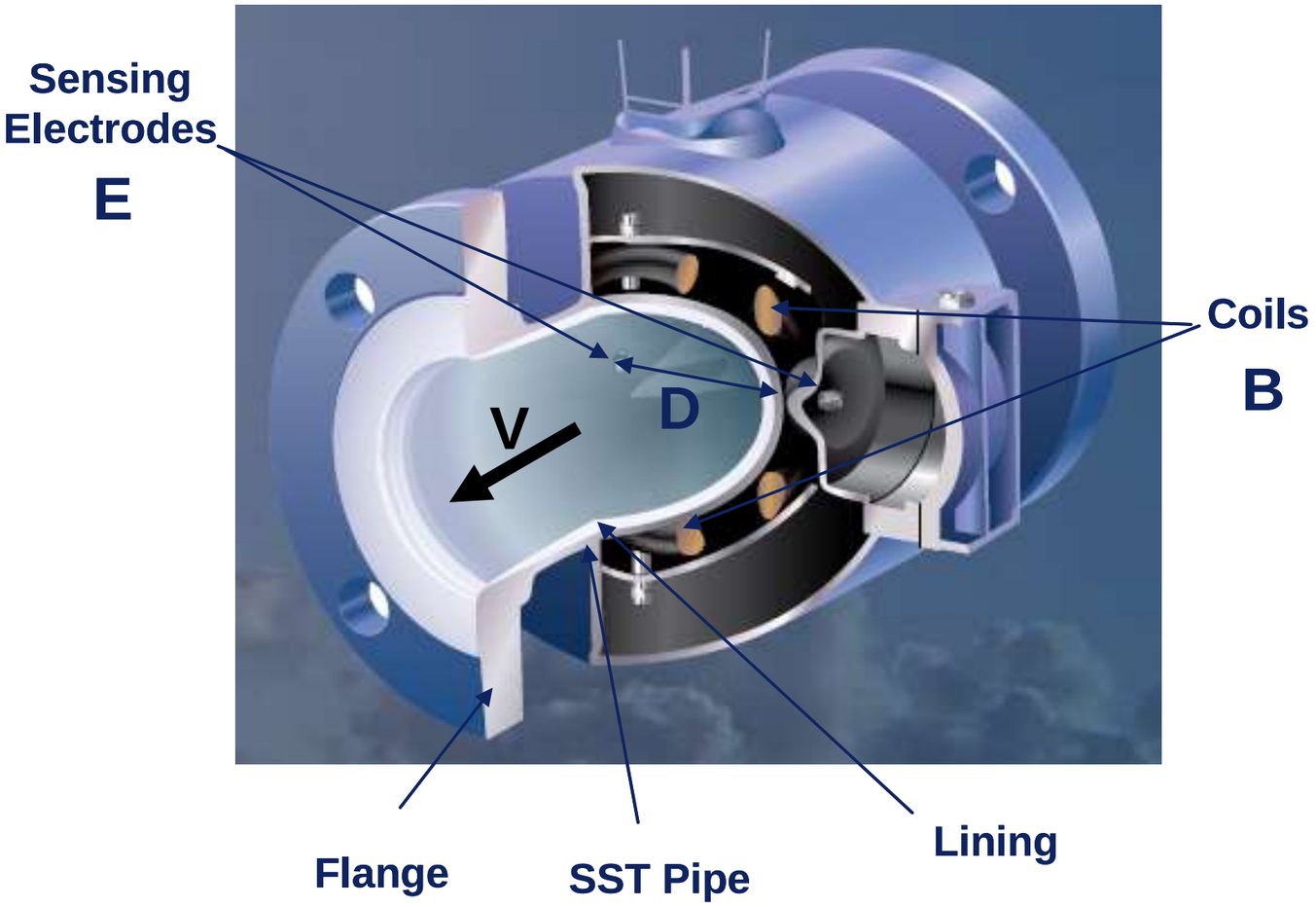
Theory of Operation: Faraday's Law

Volumetric Flow: Q = V * A
Where:
Q = Flow rate
V = Velocity
A = Area

Faraday's Law: E=kBDV
V = E/kBD
Where:
V=Velocity of conductor
k=Proportionality constant
E=Induced voltage
B=Magnetic field strength
D=Length of conductor



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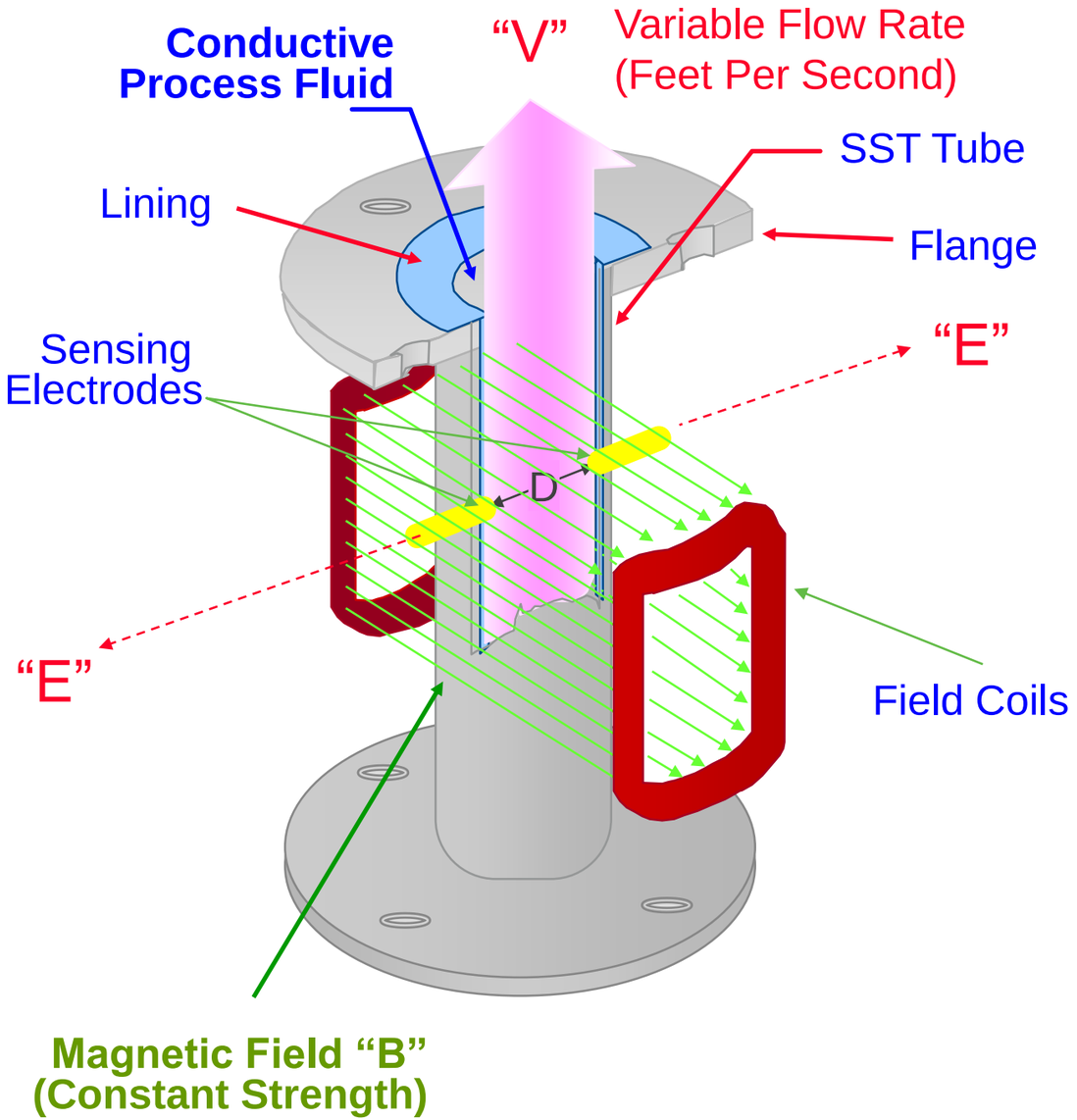
Magnetic Flow Meter Theory - Faraday's Law

Volumetric Flow: Q = V * A
Where:
Q = Flow rate
V = Velocity
A = Area

E=kBDV

k= Proportionality constant
B= Magnetic field Strength
D= Length of conductor
V= Velocity of conductor
E= Induced voltage (linear with velocity)

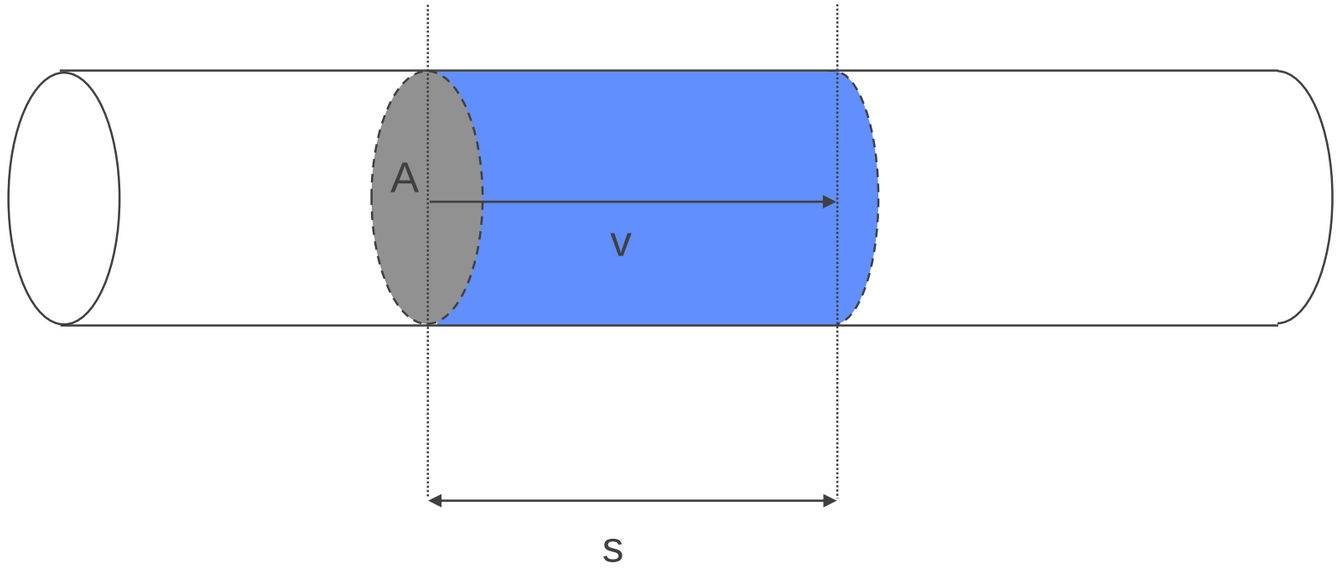


Magnetic Flow Meter Theory
Faraday's Law and the Flow Rate

- Magmeters calculate fluid velocity (V) by measuring the induced voltage (E) on the electrodes
- Q = V * A
  - Volumetric flow rate (Q) is velocity (V) times cross-sectional area (A)

E = k * B * D * V

Not effected by changes in fluid conductivity!



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Magnetic Flow Meter Theory
Fluid Conductivity

- **Magmeters Require a Conductive Process Fluid**
  - No Gases
  - No Entrapped Air, Foam, or Two-Phase Flow
  - Minimum 5 µSiemens/cm
    - **Conductance is the reciprocal of Resistance and is measured in Siemens (formerly Mhos)**
    - **10 Siemens = 0.1 Ohm**
    - **5 µSiemens/cm = 200 kOhm**

As we will see in the upcoming slides, diagnostics can help provide inside into process as well as sensor health, upset conditions, and measurement confidence by measuring things like electrode resistance, which includes conductivity

Diagnostics Improve Practices

- **STANDARD DIAGNOSTICS**
  - Transmitter Hardware Fault
  - Transmitter Software Fault
  - Sensor Coil Fault
  - Empty Pipe

- DA1 HART DIAGNOSTICS
  - Grounding and Wiring Fault
  - High Process Noise
  - Coated Electrode Detection (8732E)

- DA2 HART DIAGNOSTIC
  - SMART™ Meter Verification
    - Continuous (8732E)

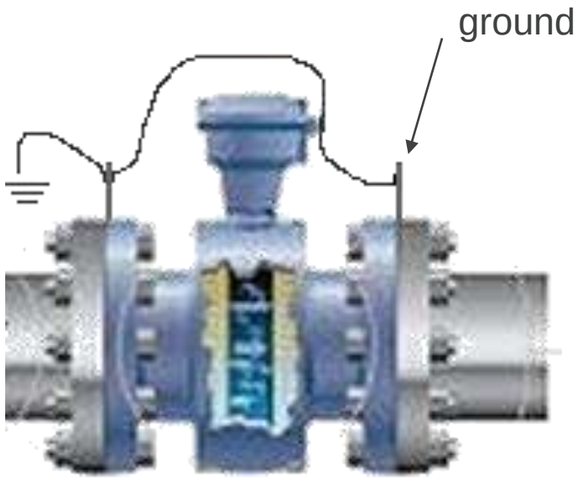
- D01 DIAGNOSTICS (8732E)
  - Grounding and Wiring Fault
  - High Process Noise

- D02 DIAGNOSTIC (8732E)
  - SMART™ Meter Verification

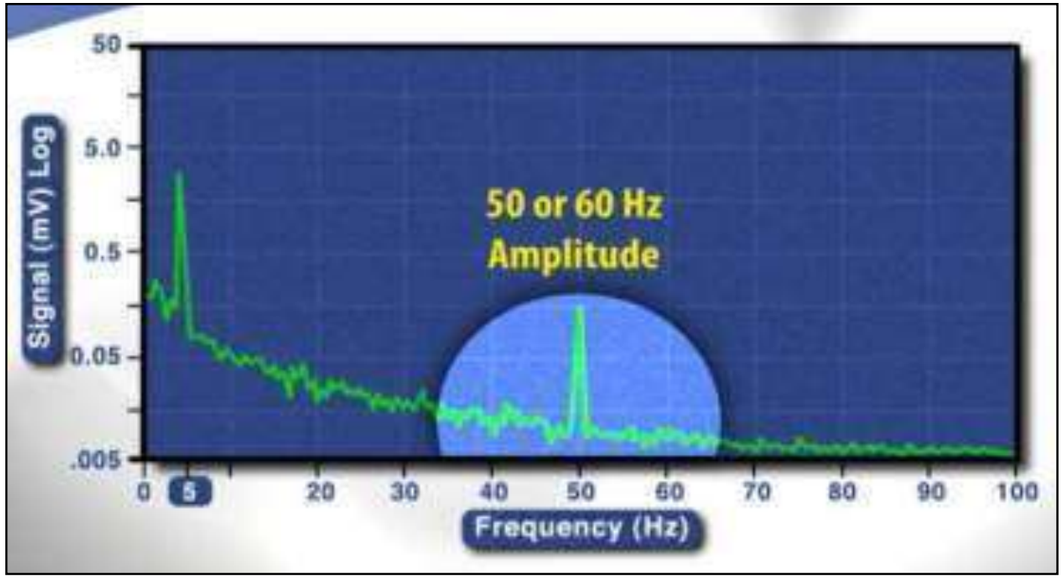
Ground & Wiring Fault Detection Improves Installations

I Would Like To Be Sure my Magmeter is Installed Right The First Time.

It Would Reduce Start-up Time and Cost.

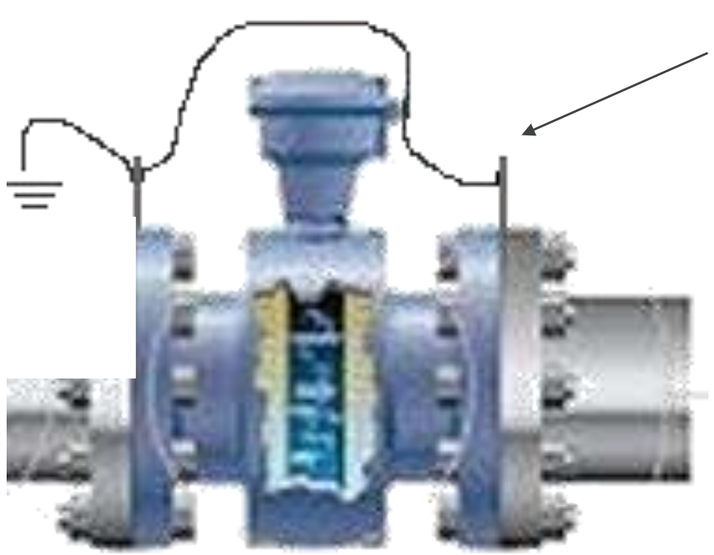


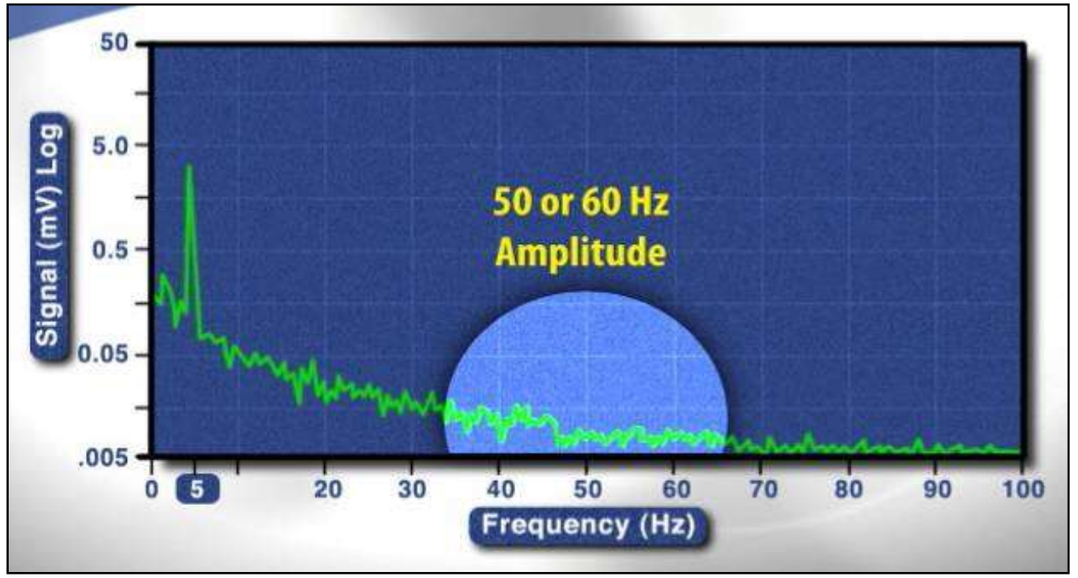
- Improper grounding is a leading cause of flow measurement issues with magnetic flow meters
- Rosemount Grounding and Wiring Fault Detection monitors the entire frequency spectrum to recognize if AC noise is effecting the flow reading – and alerts you if it is

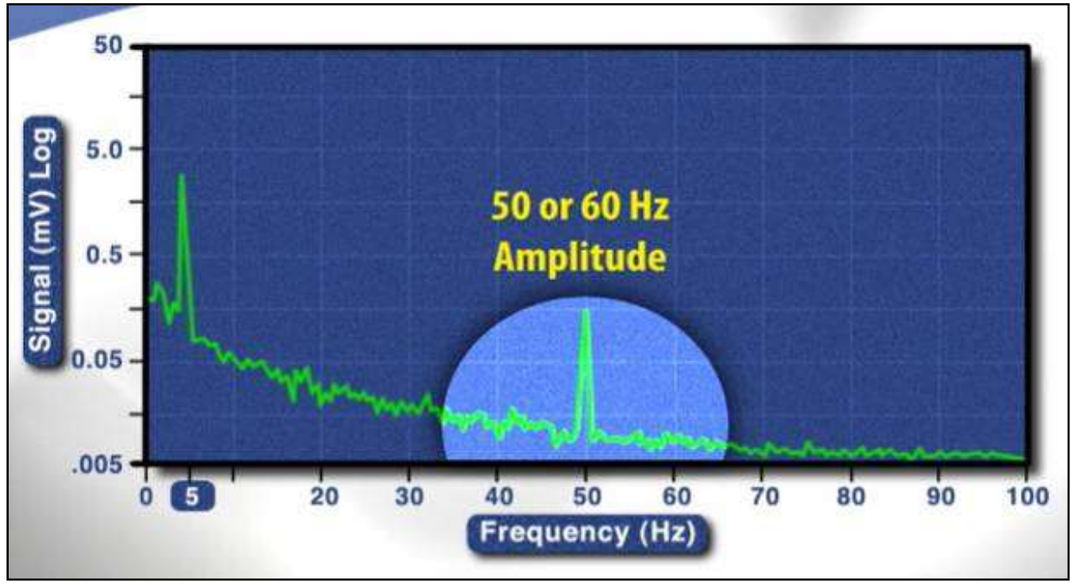


Magnetic Flow meter Diagnostic Ensures Proper Installation

- Proper grounding is critical to deliver the best measurement from magnetic flowmeters
- The magmeter as a built-in spectral analyzer to ensure no 50 or 60 Hz noise is present

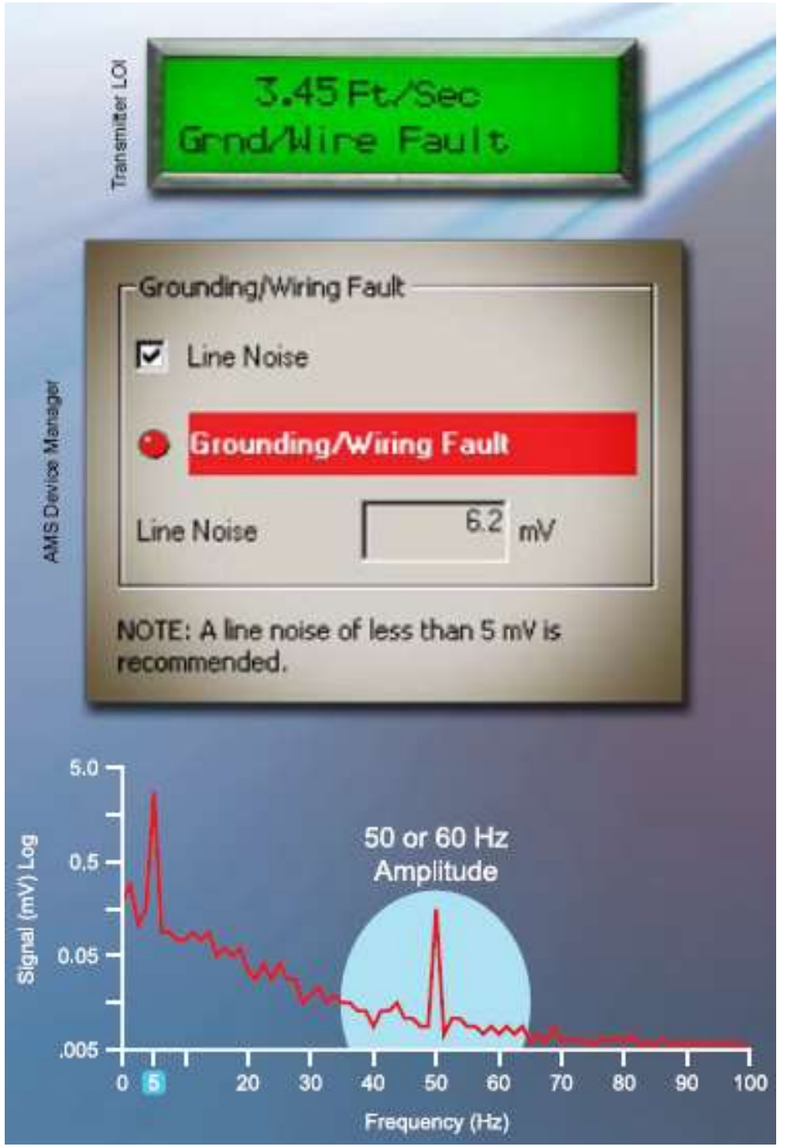






Ground & Wiring Fault Detection Ensures Proper Installation

If excessive voltage is seen at 50 or 60 Hz frequency range, an alert is given to confirm that wiring has been done properly



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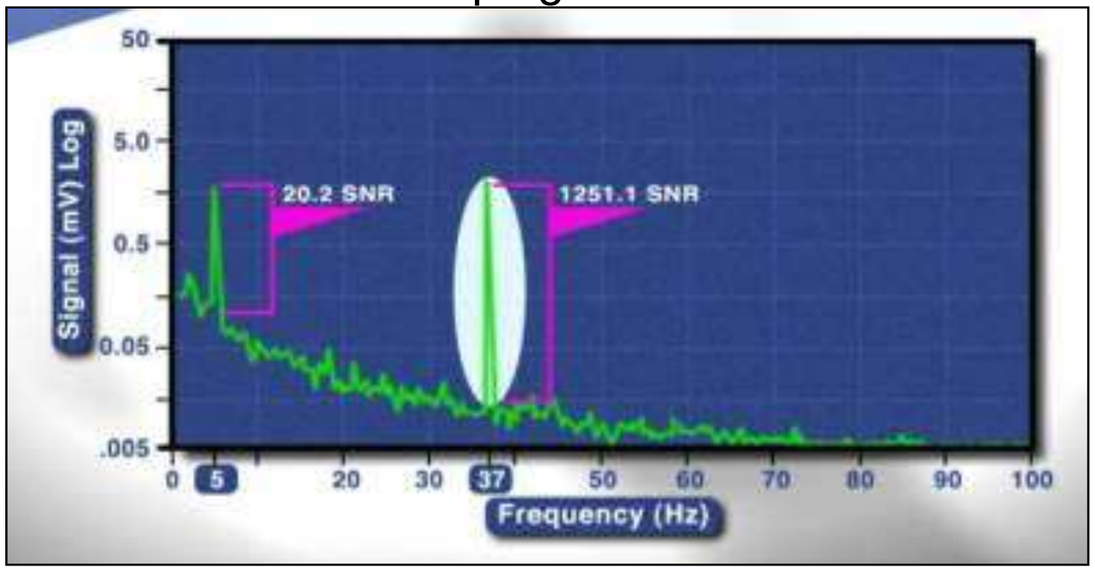
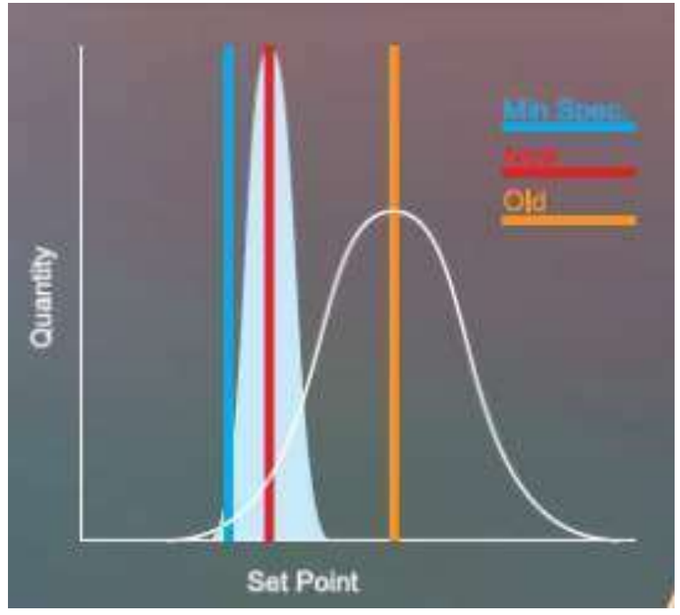
Process Noise Makes Optimization and Maintenance a Tougher Job

I Would Like to Reduce Valve Wear-out, But Also Improve Process Performance.

It Would Reduce Maintenance as well as variability and uncertainty

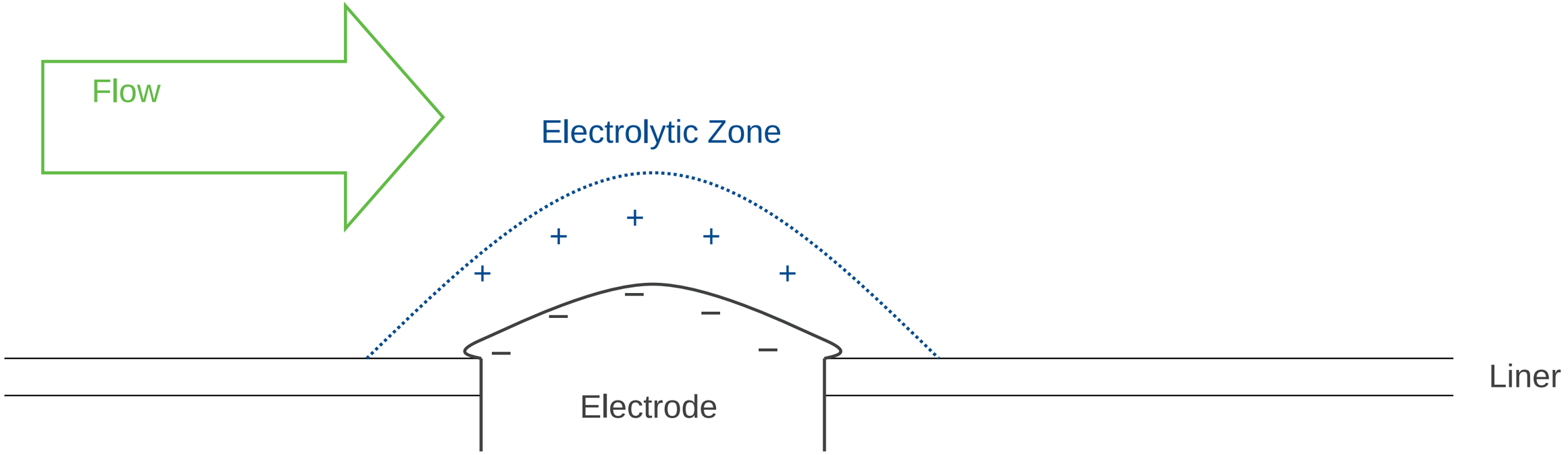
- Slurries create noisy output resulting in valve actuation – so high levels of damping are common
- Damping = control loop dead-time
- Damping makes the flow signal look stable - but the valve will not change position rapidly - even when real flow rates change – adding real process variability
- Rosemount High Process Noise Diagnostic and User-selectable Coil Drive provides Maximum Stability with Minimum Damping





Process Noise

- Caused by disturbance of electrolytic zone around electrodes head
  - Exchange of ions between electrode and conductive process fluid
  - Measuring a flow signal on the magnitude of several hundred microvolts to a few millivolts



Process Noise Profiles

- 1/F Noise
- Spike Noise
- White Noise

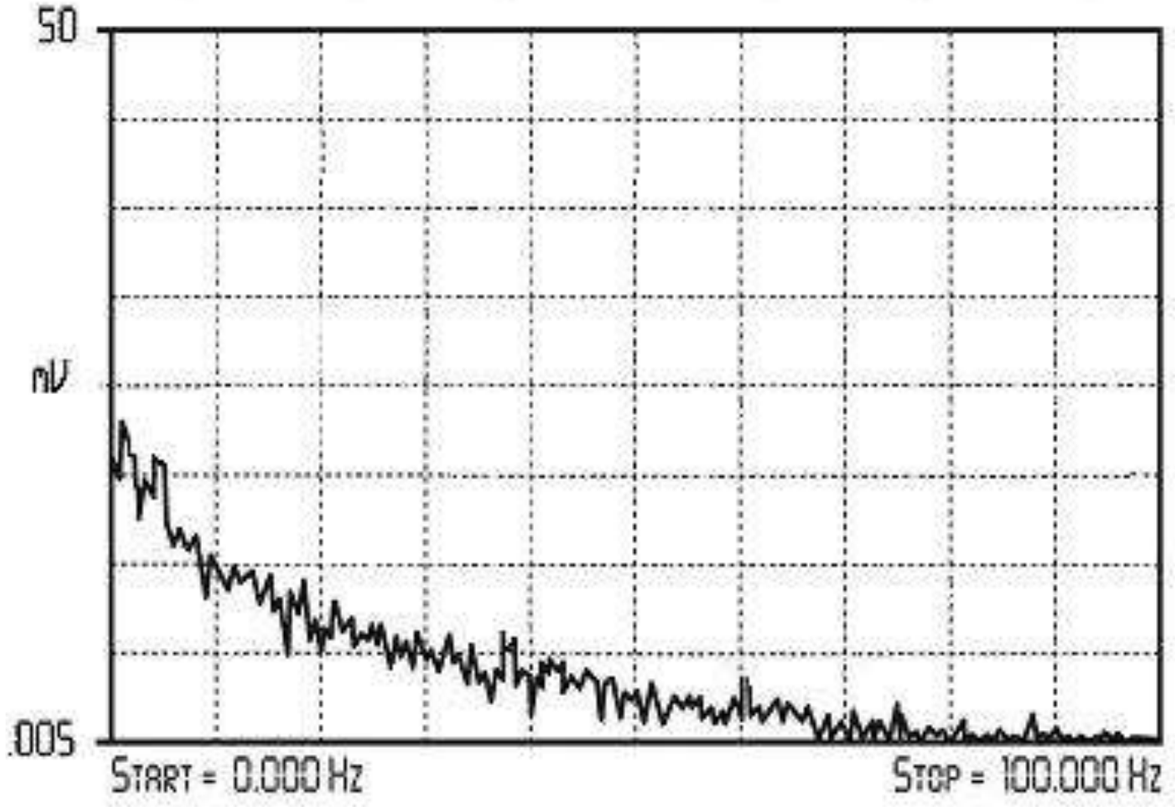
Different Noise Profiles are Caused by different Process Conditions

Diagnostics can determine which conditions may exist

Drive Frequency and DSP can be used to handle and correct these conditions

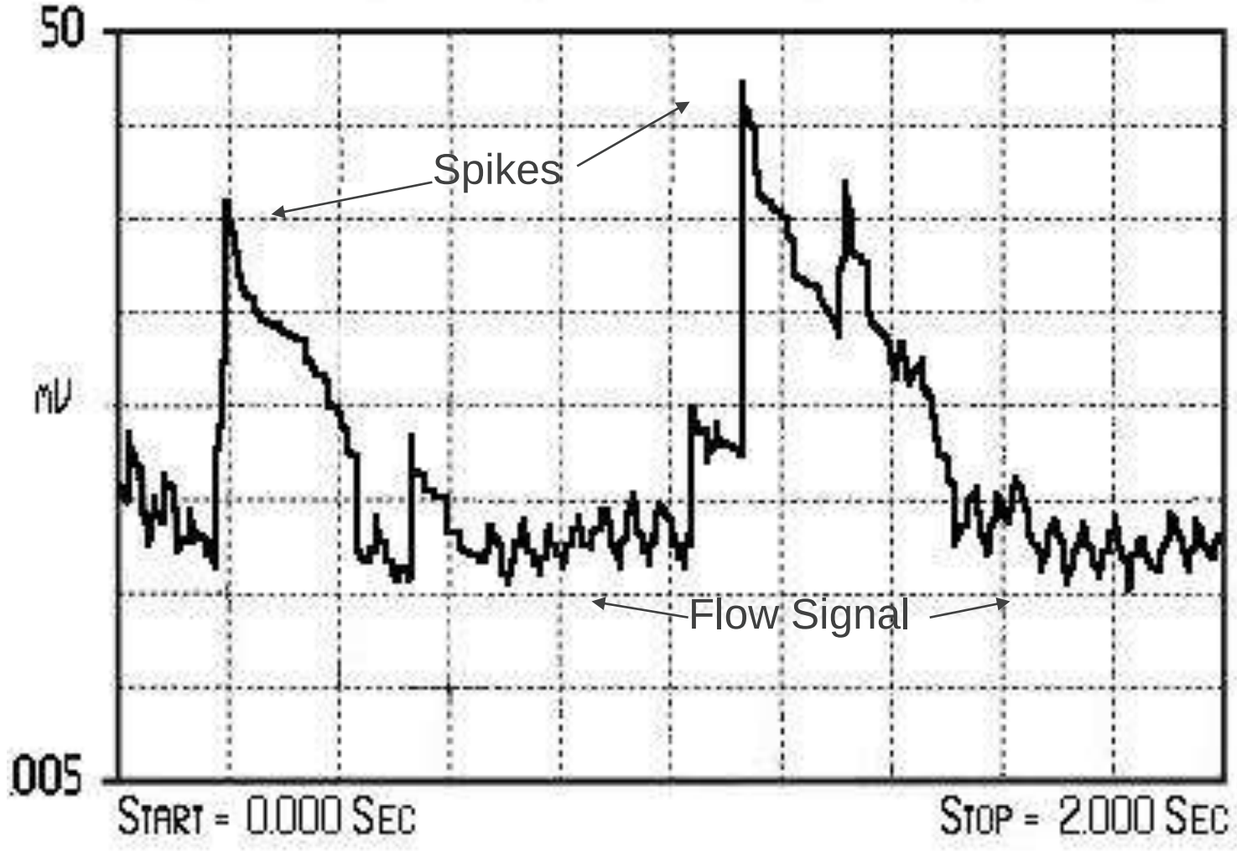
Typical Noise Profile (1/F)

- 1/F Noise
  - Characterized by a frequency spectrum in which the amplitude of the noise decreases with increasing frequency
  - Corner frequency usually less than 10 Hz
  - *Lower consistency pulp flows, chemical additions*



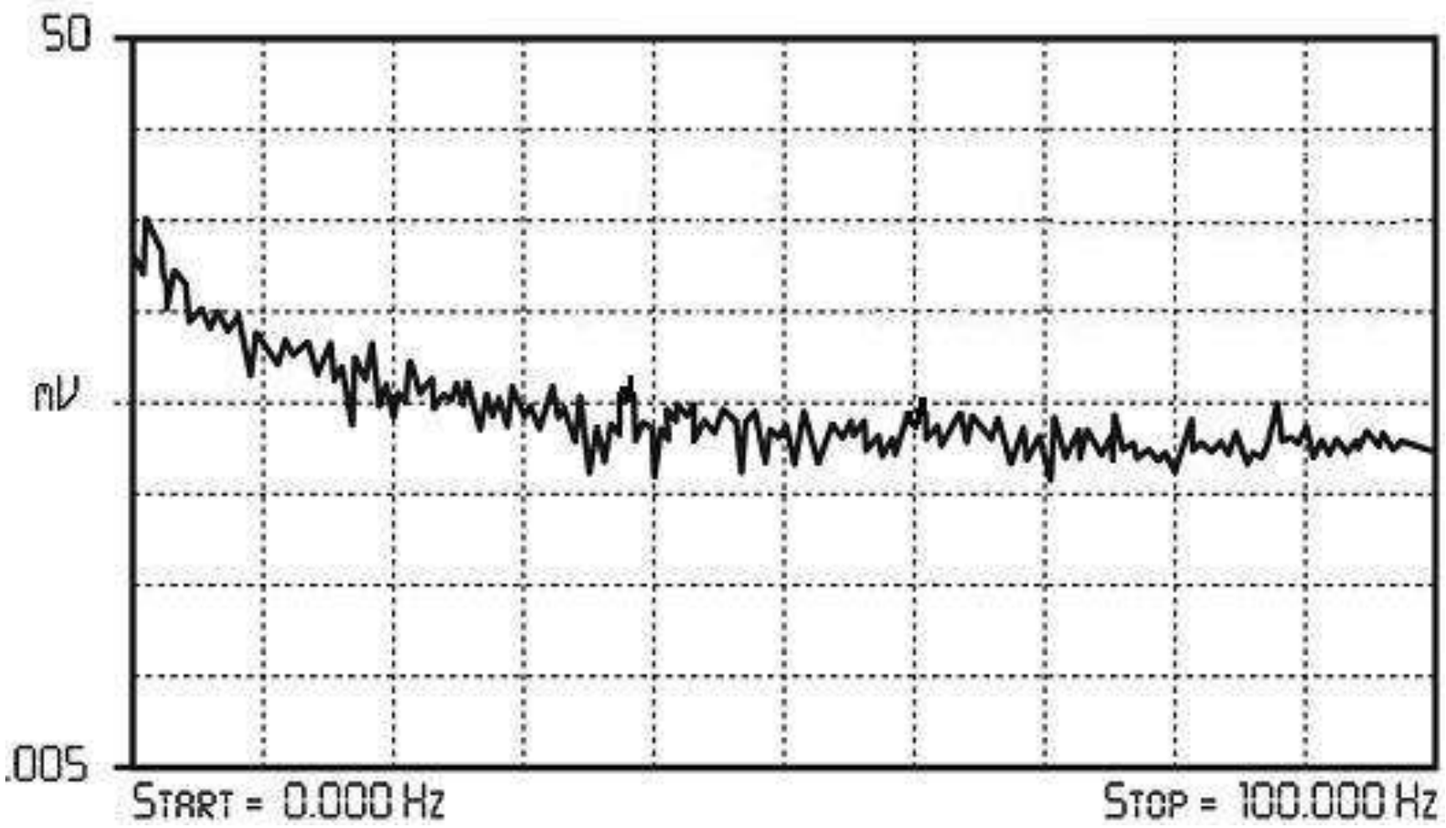
Spike Noise Profile

- Spike Noise
  - Characterized by large voltage spikes generated by the impact of solids on the electrode head
  - Spikes can be generated at any frequency
  - *Medium consistency pulp flows, Large Particles*



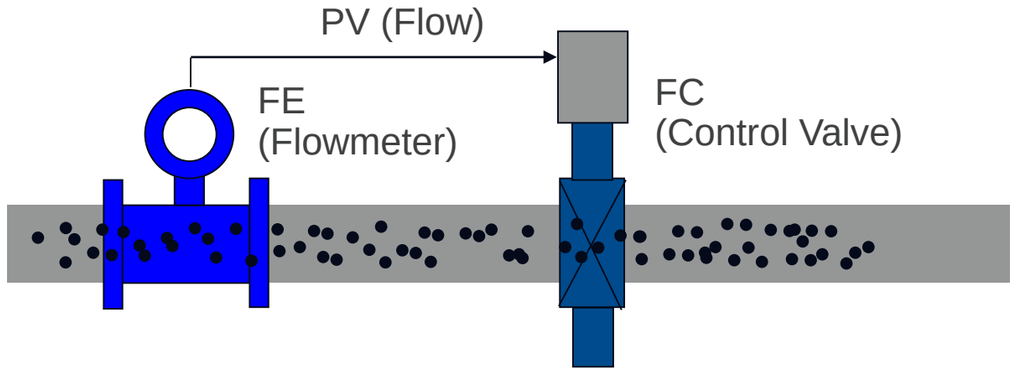
White Noise Profile

- White Noise
  - Characterized by essentially constant high noise amplitude
  - Noise covers entire frequency range (out to several hundred Hz)
  - *Medium/High consistency pulp flows, Hydraulic disturbances created by nearby pumps or valves*

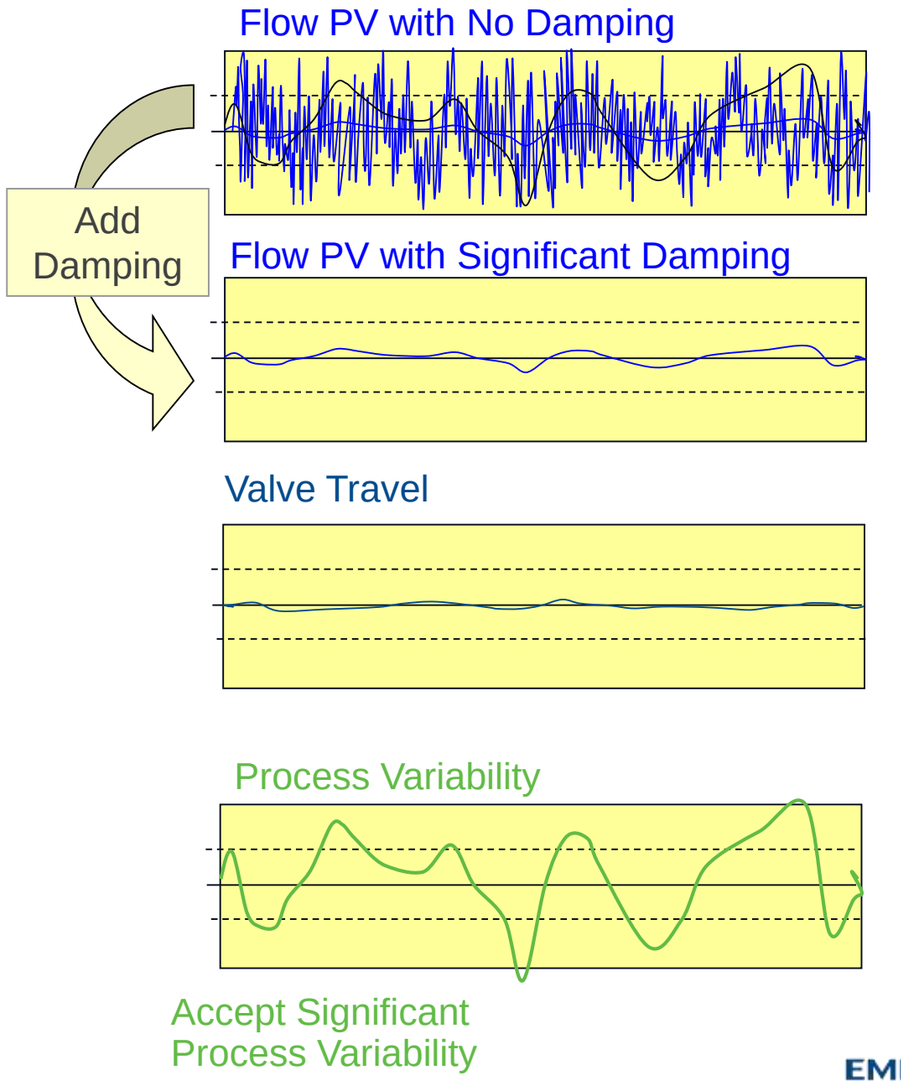


Flow Optimization
Damping in Noisy Application

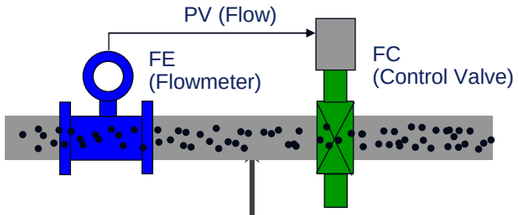
Control Loop – with Damping



- Flowmeter (FE)
  - Looks Stable, slow to respond to real changes
- Valve (FC)
  - Looks stable, slow to control real changes
- Process
  - Very Inconsistent, out of control, varying quality

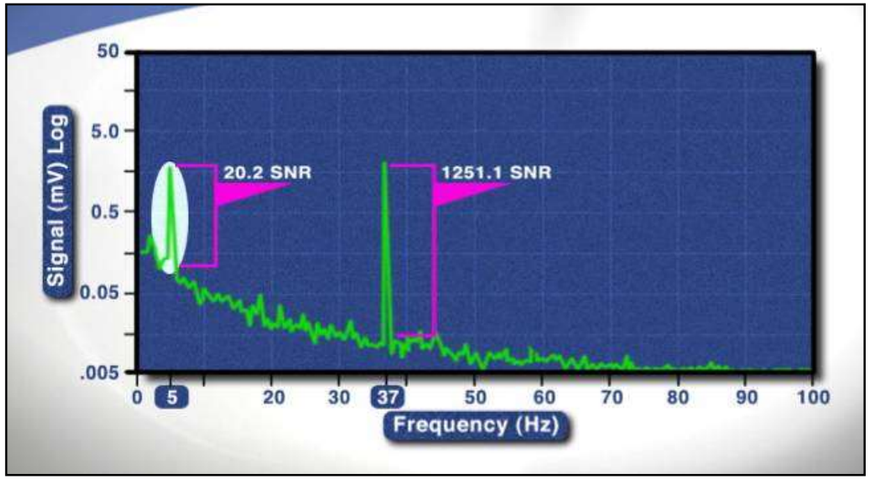


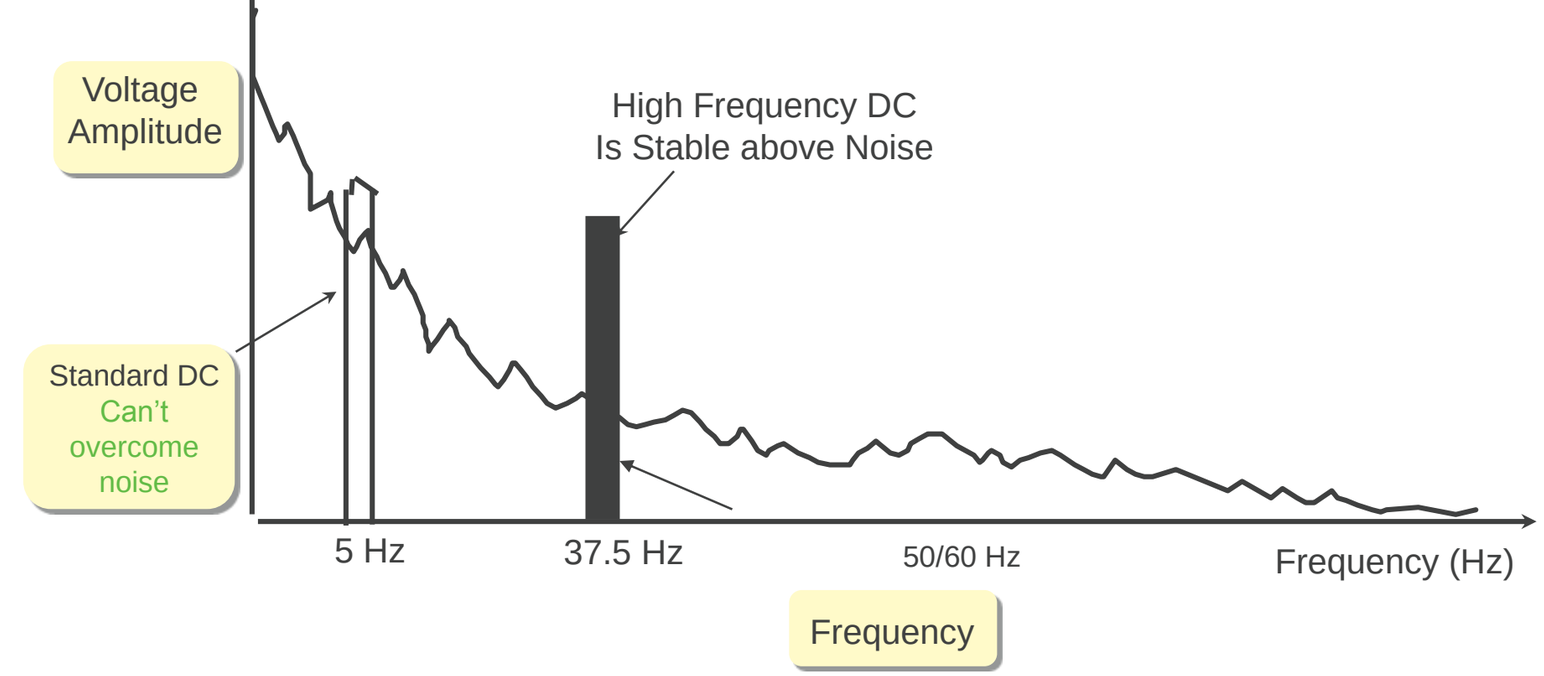
Process Noise Applications – High Frequency

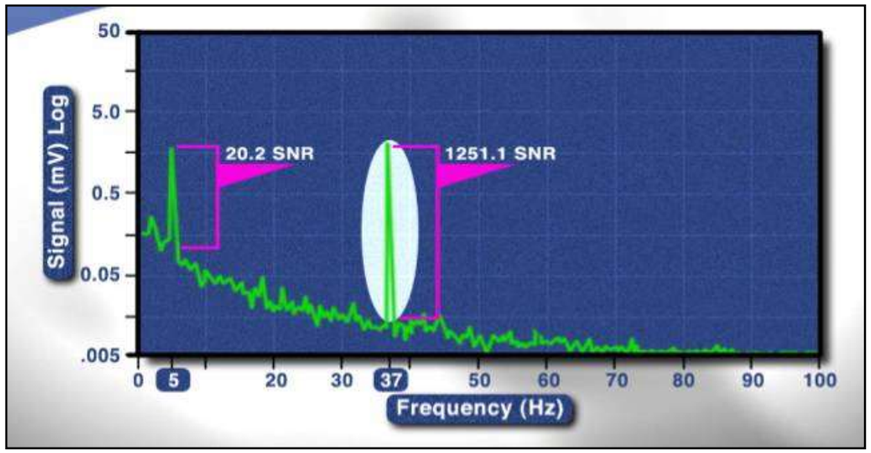


Much higher SNR.

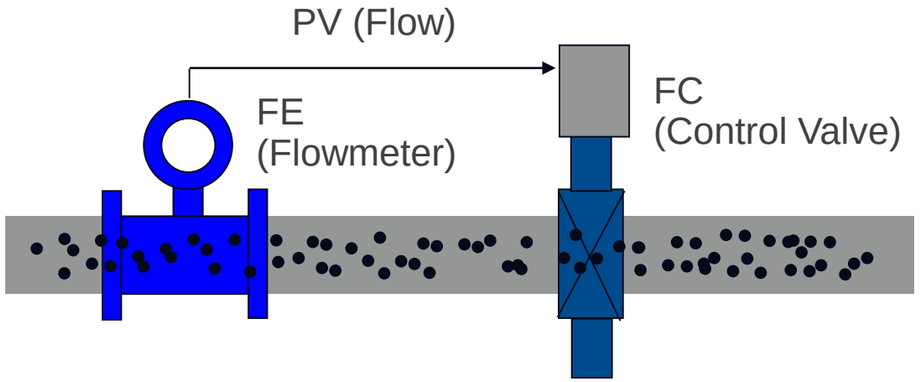
The higher the SNR, the more stable the signal!

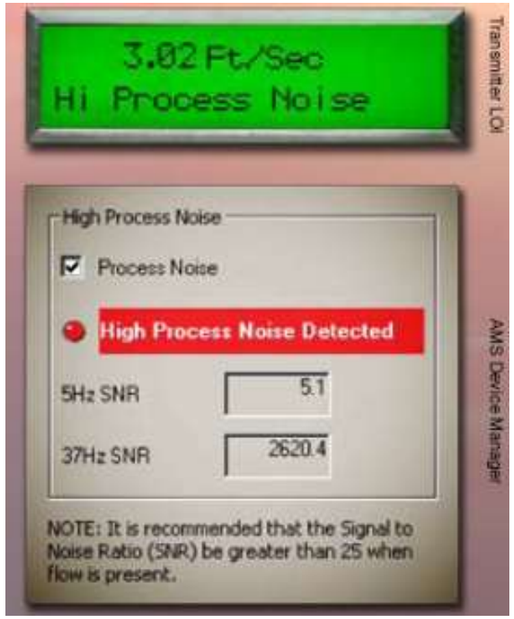


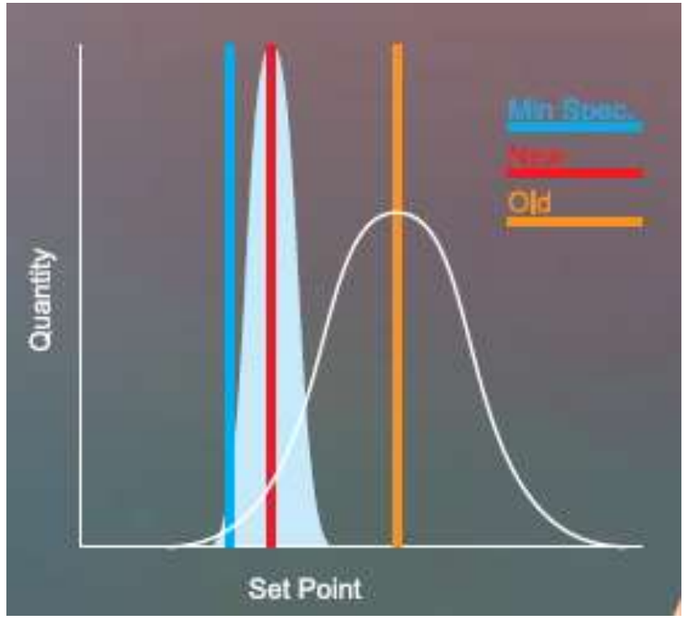




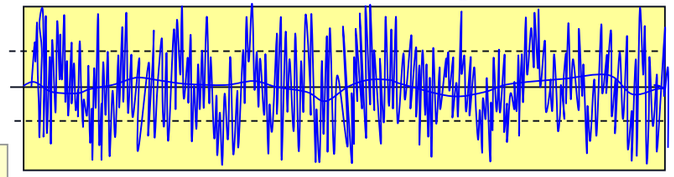
Flow Optimization in Noisy Applications





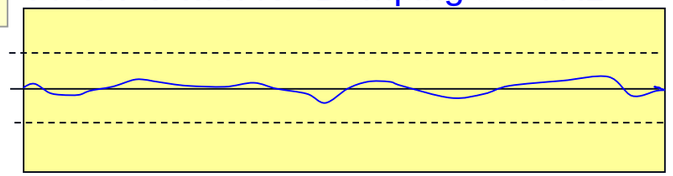


Flow PV with No Damping at 5HZ

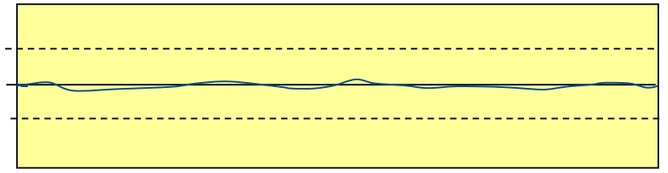


Move to 37Hz

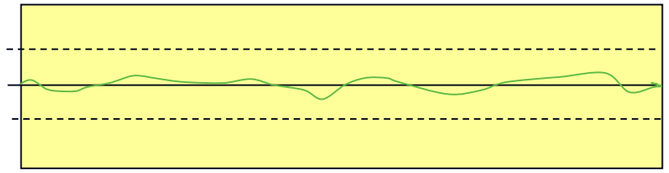
Flow PV with No Damping at 37Hz



Valve Travel



Process Variability



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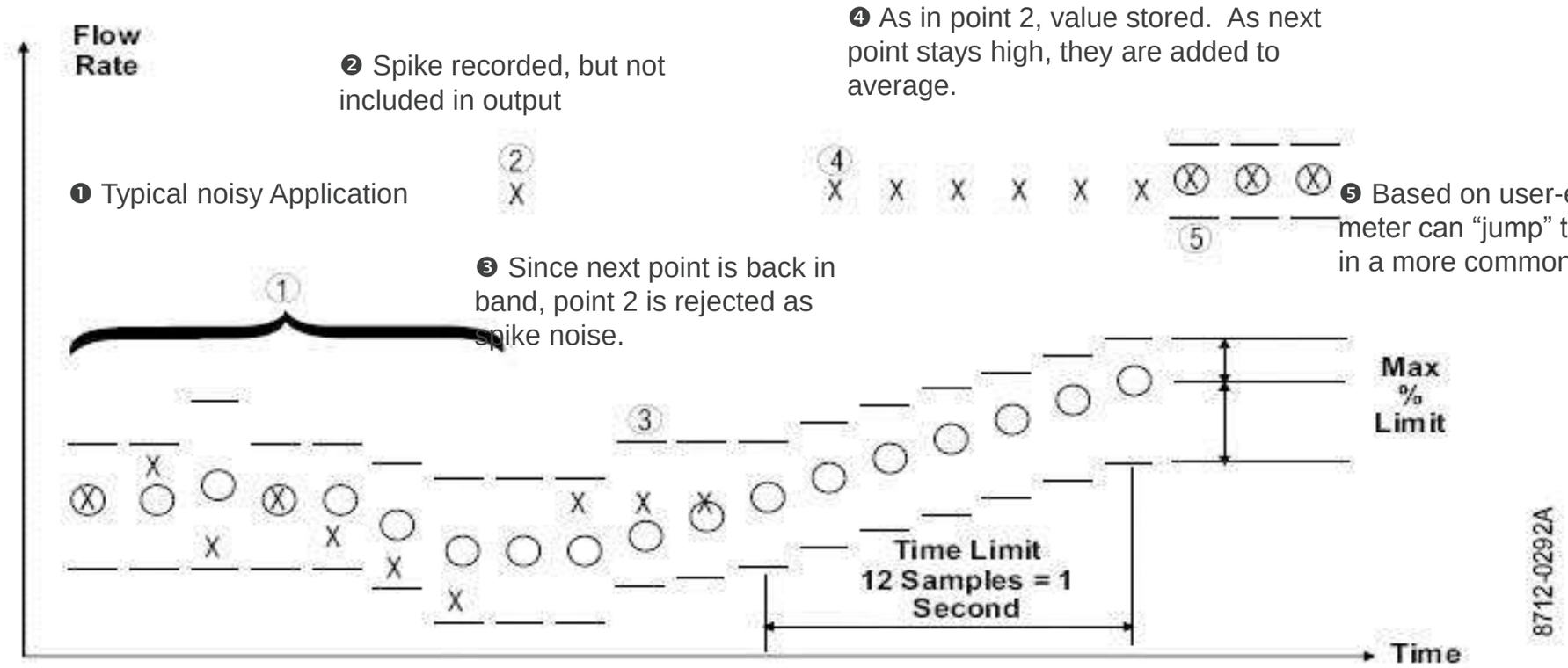
Digital Signal Processing



X: Input flow signal from flowtube.

O: Average flow signals and transmitter output, determined by the "number of samples" parameter.

Tolerance band, determined by the "percent limit" parameter.
– Upper value = average flow + [(percent limit/100) average flow]
– Lower value = average flow – [(percent limit/100) average flow]

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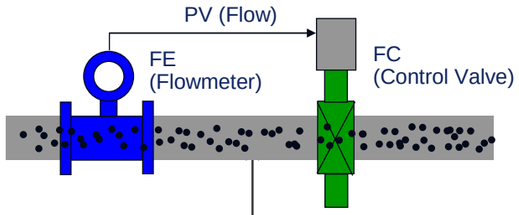
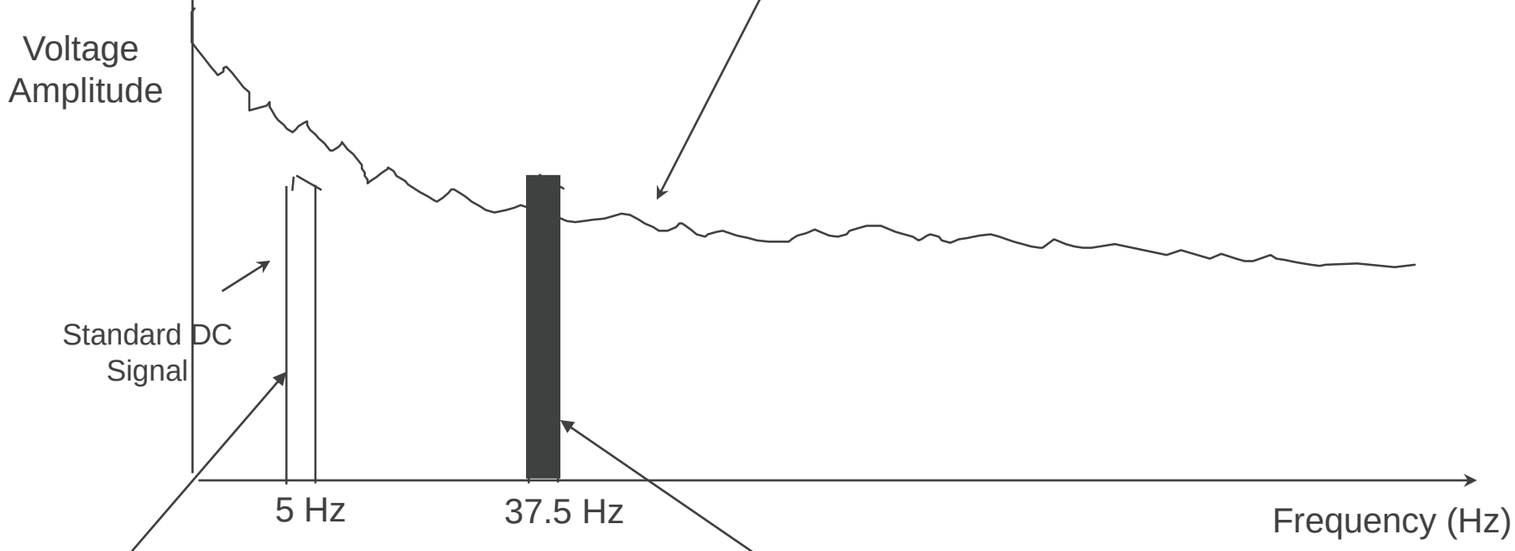
Process Noise Applications – High Frequency



If very high levels of 1/f or white noise is present, HIGH SIGNAL DC will be required



Very low Signal to Noise Ratio (SNR)

37 Hz will not address very high levels of 1/f or white noise

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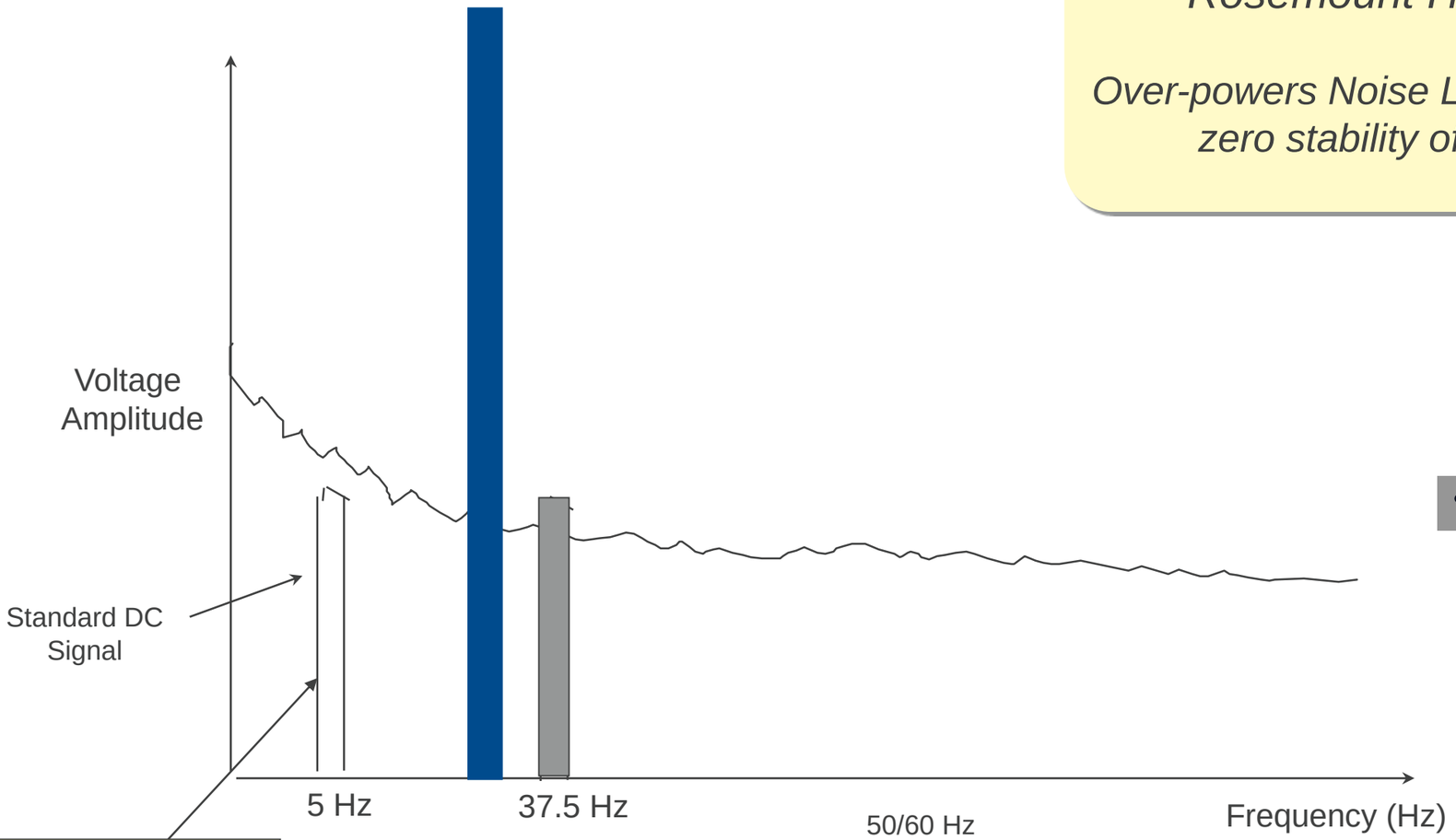
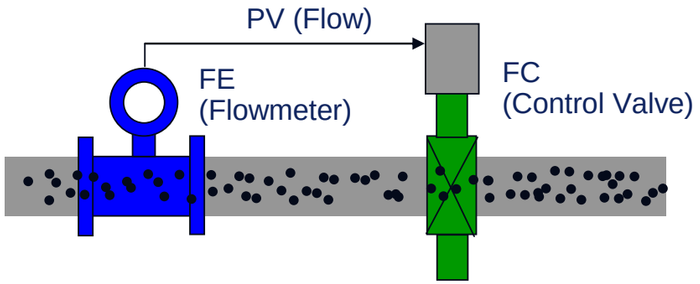
Process Noise Applications – High Signal DC

Rosemount High-Signal™

Over-powers Noise Like an AC, Delivers zero stability of a pulsed DC





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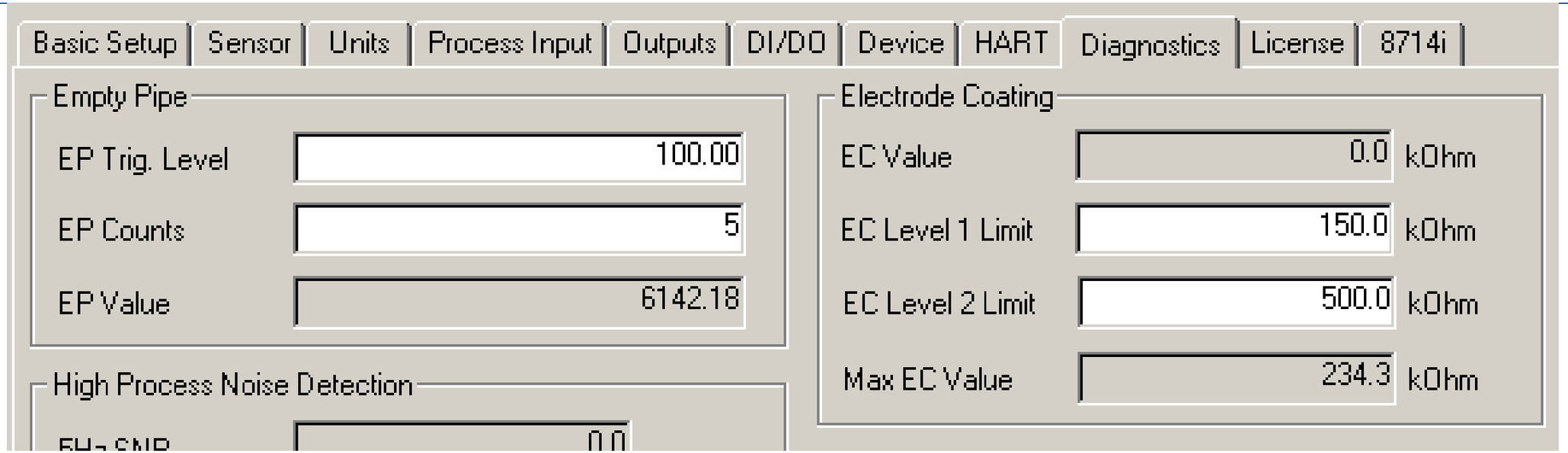
Coated Electrode Detection in AMS, Prolink II, or Digital Comm



- 2 levels of electrode coating to set
  - Limit 1 – indicates when coating is starting to occur, but has not compromised the flow measurement
  - Limit 2 – coating is now affecting the flow measurement and the meter should be serviced immediately
  - Default Limits 1000 and 3000 kOhm….EVERY PROCESS IS DIFFERENT!
- Best Practices
  - Record EC Value with New, Clean, Full sensor
  - Record EC Value when coating creates unreliable readings
  - Sett Limit 1 based on Maintenance Schedule

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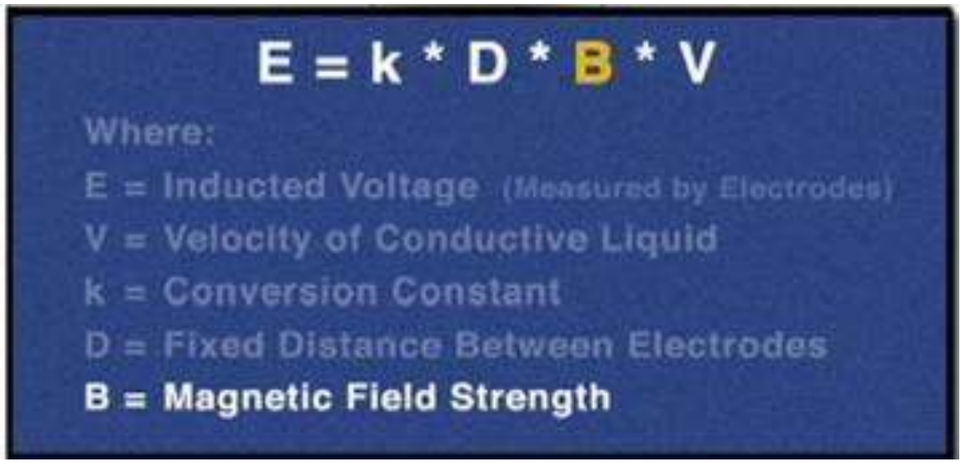
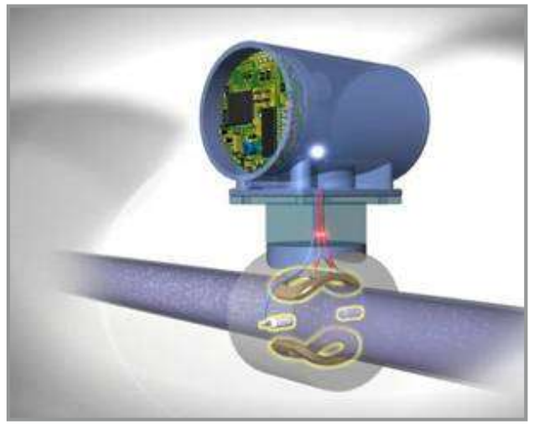
SMART Meter Verification Greatly Reduces Calibration Verification Costs

I Would Like to Verify the Magmeter Calibration Without Removing It From The Line Or Using Extra Equipment .

It Would Reduce Maintenance Time and Cost.





- Verifying mag calibration historically involved removing the flowmeter from the line or using extra equipment
- Rosemount SMART™ Meter Verification Diagnostic provides calibration verification without removing the product from the line or requiring the purchase of extra equipment

Sensor Parameter	Signature Baseline Values	8714i Measure Values	Deviation	Criteria	Pass /Fail
Coil Signature	**19.5**	**19.6**	**0.51%**	**1%**	**Pass**
Coil Resistance	15.2	15.6		Range	**Pass**
Electrode Resistance	260.7	245.6		Range	**Pass**

Terminology:
Calibration, Validation, and Verification

- Definition of terms
  - *Calibration*: Establishing the relationship between flow and signal produced by sensor.
  - *Validation*: Confirming flow performance by comparing a primary flow standard to sensor
  - *Verification*: Establishing confidence in performance by analysis of secondary variables associated with flow
- Frequently these terms are used interchangeably
- Many times calibration or validation is done when only verification is needed
- Emerson baselines an indicating parameter at time of factory calibration that can be self-checked to perform ongoing verification of the meters calibration and health
  - In addition to Electronics Verifications, Rosemount Magmeters use:
    - Magnetic field signature (inductance)
    - Coil Resistance
    - Electrode Resistance

Verification uses a secondary means to show nothing has changed to alter the calibration

Verification tests every part of the entire measurement system

Verification tests against a baseline

Historically Verifying Meters has been time-consuming and forced shutdown

Prover

Must shutdown, remove meter from the line, pay for proving.

External Equipment

- Trip to field
- Technical knowledge and Extra equipment
- No formal report
- No deviation values
- More than 120 minutes
- May require a process shutdown

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Meter Verification Theory of Operation

- A baseline signature of the magnetic field is taken at the time of factory calibration
  - Signature is independent of temperature and flow-rate
  - Signature (and calibration) will change if there is a mechanical shift of the coils over time due to vibration, thermal cycling, etc

$$E = k * D * B * V$$

Where:

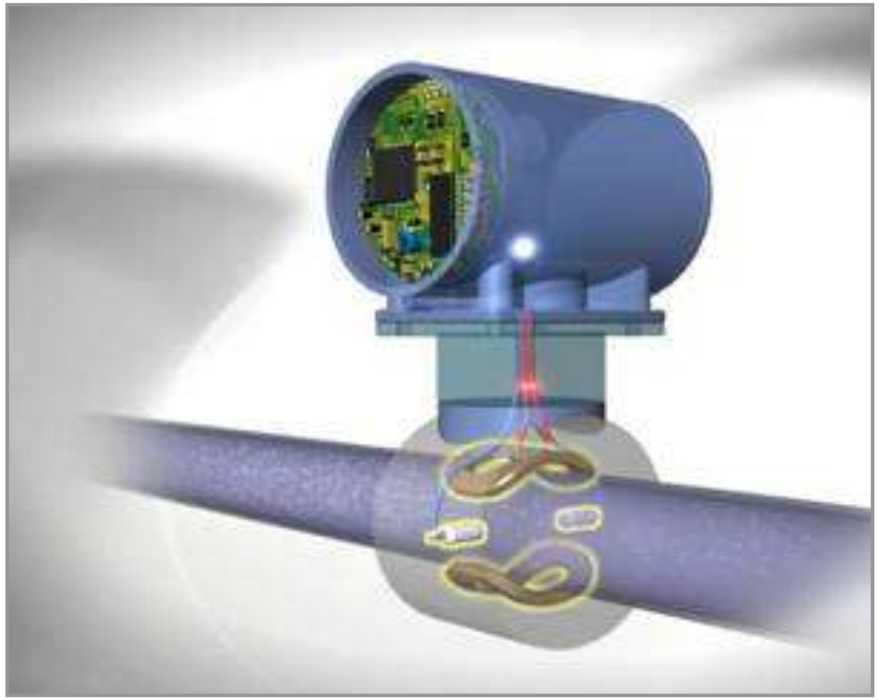
E = Inducted Voltage (Measured by Electrodes)

V = Velocity of Conductive Liquid

k = Conversion Constant

D = Fixed Distance Between Electrodes

B = Magnetic Field Strength



A Field Baseline Must Be Performed to Establish Electrode Resistance on the Process

Meter Verification Delivers Pass/Fail for Calibration and Health

8714i Meter Verification

- Compares measured coil signature to baseline coil signature
- % deviation is calculated
- User assigns acceptance criteria based on application
- Verifies the health of coil and electrode circuits

Established at factory calibration

Measured in the field

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Coil Signature	**19.5**	**19.6**			
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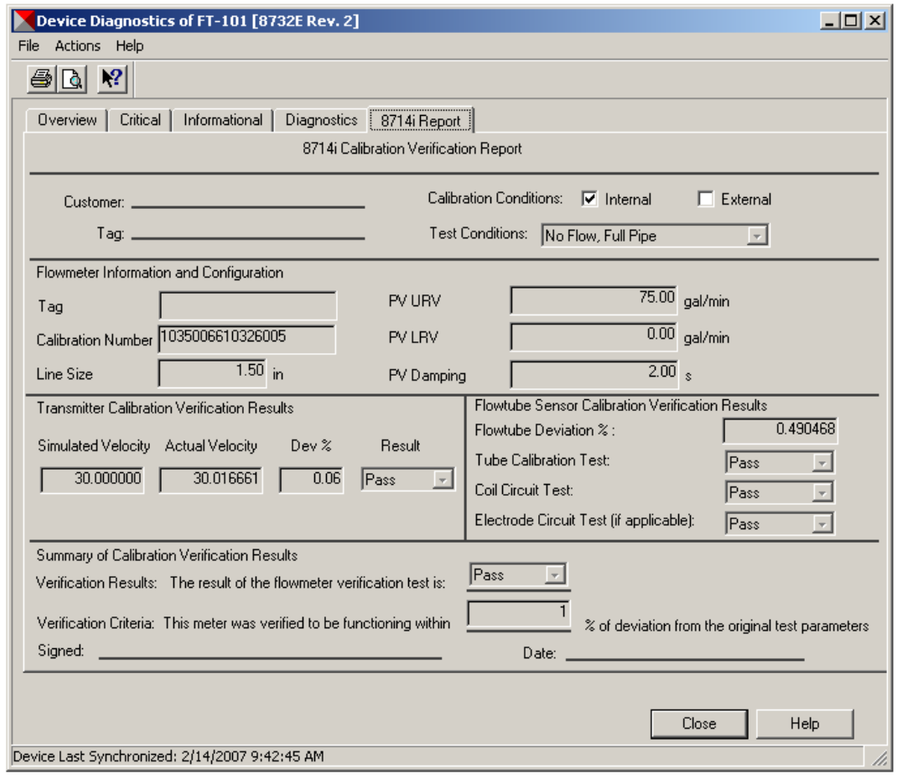
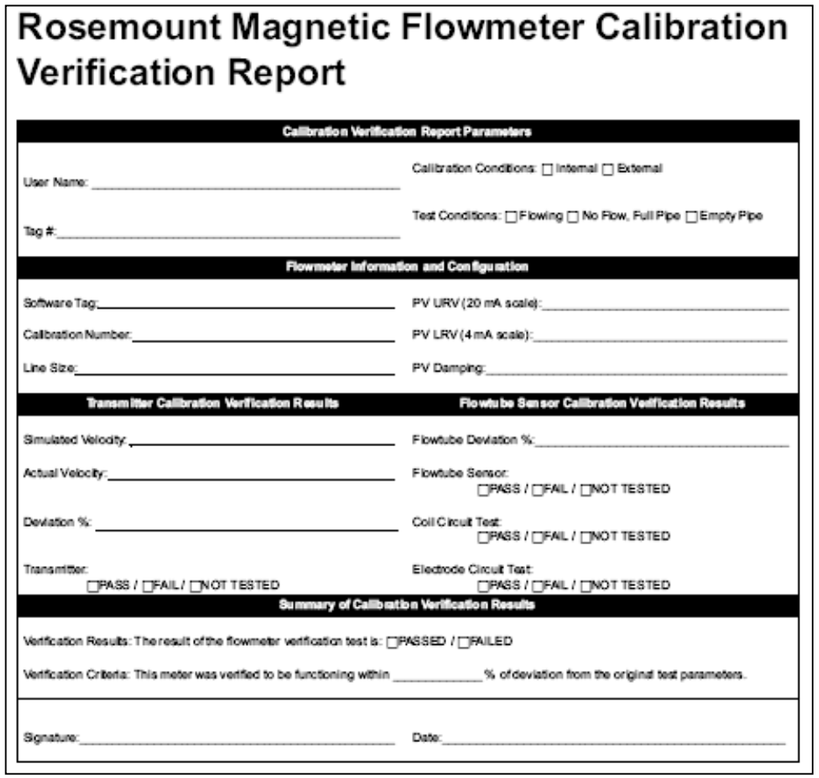
Meter Verification Offering Provides Options for Documentation



Report from AMS

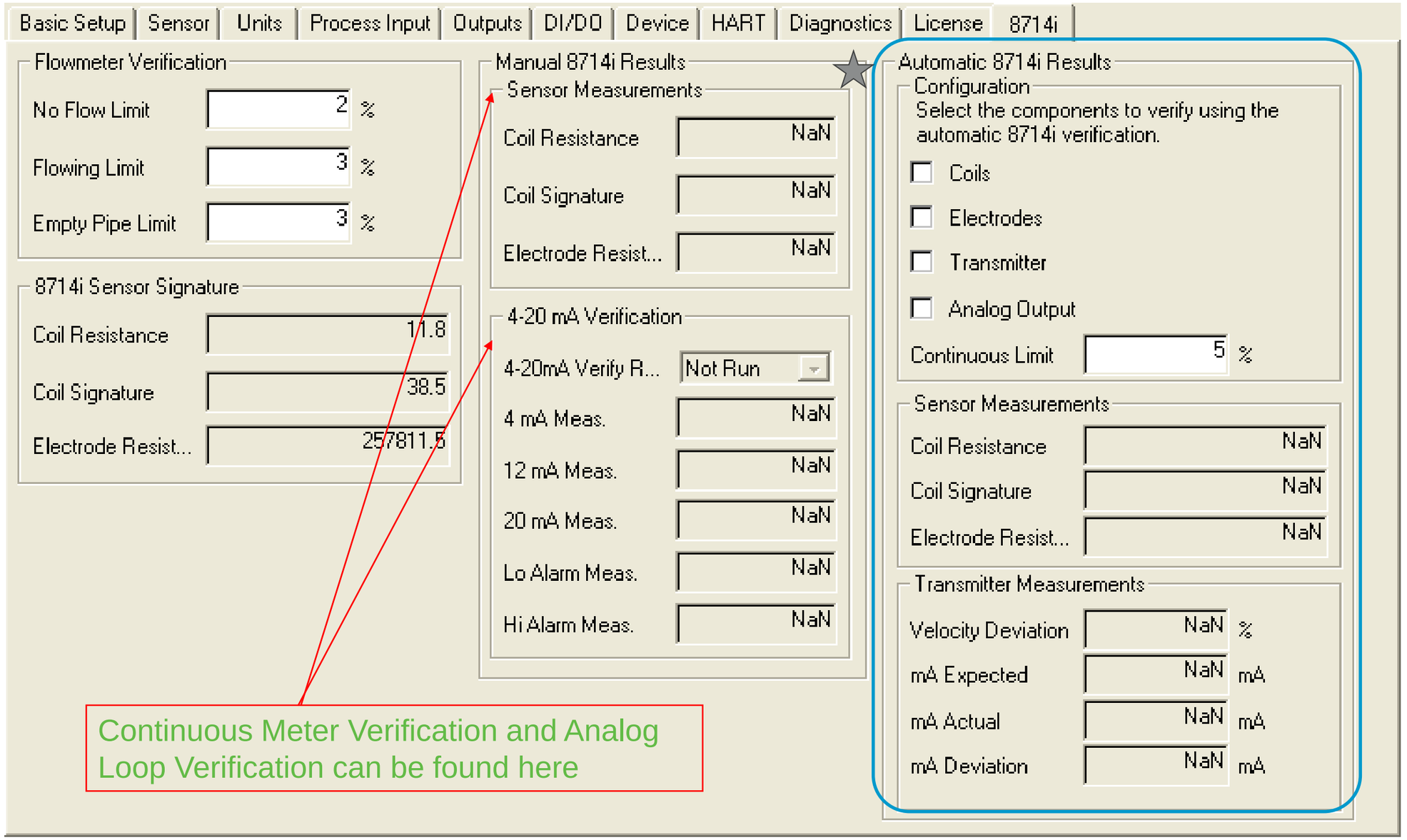


Manual Verification Report

Available in Reference Manual or Rosemount.com

Prolink III Report

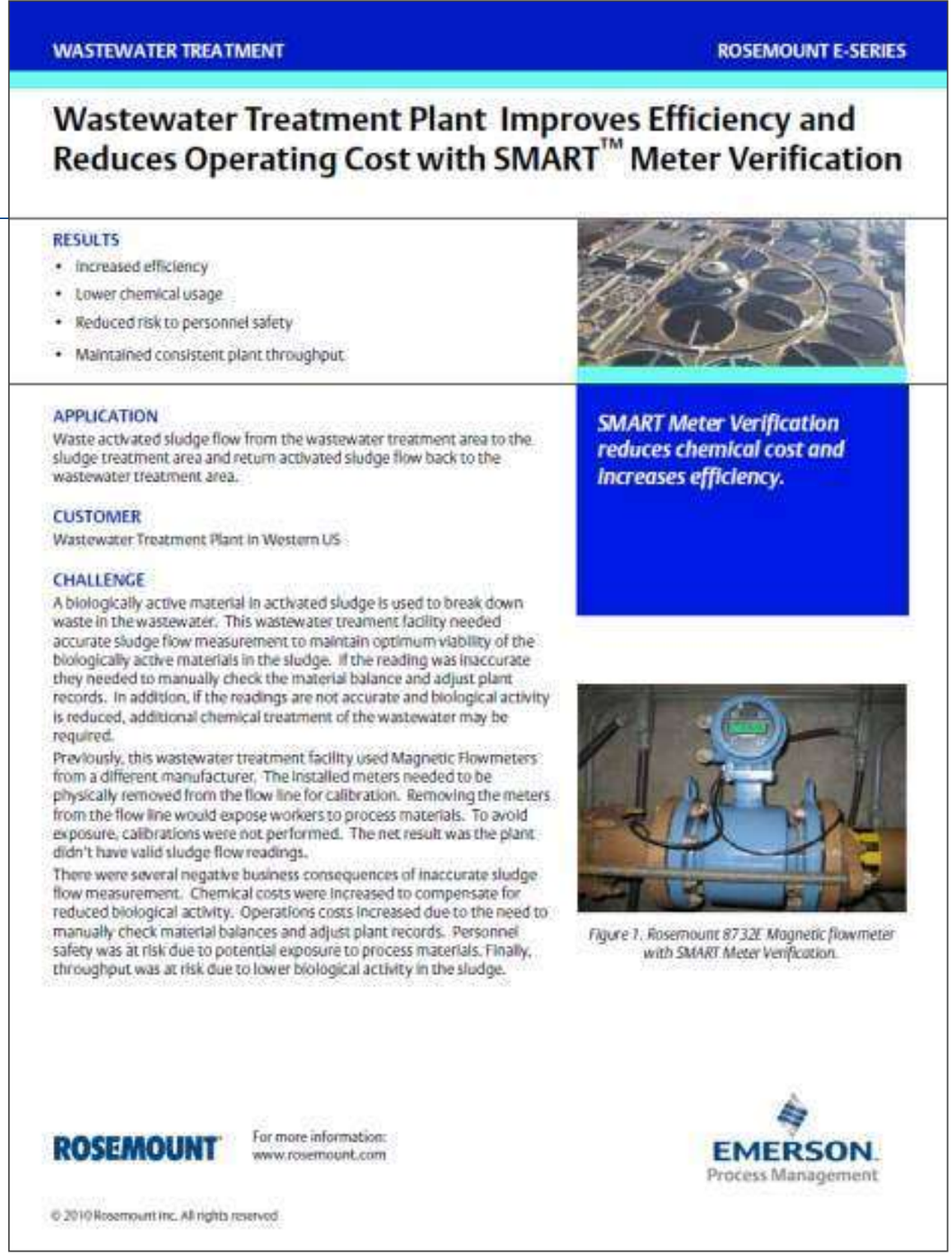
Continuous SMART Meter Verification is always running



Diagnostics Matter: Proven Results

The SMART™ Meter Verification diagnostic enabled this wastewater treatment plant to reduce their chemical usage and improve throughput.

- Waste activated sludge
- Meter verification required for this flow point in order to verify that biological activity was kept at correct levels
- SMART™ Meter Verification allowed this plant to extend time between meter removal increasing the process efficiency and reducing maintenance costs
- 00830-1200-4727



WASTEWATER TREATMENT ROSEMOUNT E-SERIES

Wastewater Treatment Plant Improves Efficiency and Reduces Operating Cost with SMART™ Meter Verification

RESULTS

- Increased efficiency
- Lower chemical usage
- Reduced risk to personnel safety
- Maintained consistent plant throughput

APPLICATION

Waste activated sludge flow from the wastewater treatment area to the sludge treatment area and return activated sludge flow back to the wastewater treatment area.

CUSTOMER

Wastewater Treatment Plant in Western US

CHALLENGE

A biologically active material in activated sludge is used to break down waste in the wastewater. This wastewater treament facility needed accurate sludge flow measurement to maintain optimum viability of the biologically active materials in the sludge. If the reading was inaccurate they needed to manually check the material balance and adjust plant records. In addition, if the readings are not accurate and biological activity is reduced, additional chemical treatment of the wastewater may be required.

Previously, this wastewater treatment facility used Magnetic Flowmeters from a different manufacturer. The installed meters needed to be physically removed from the flow line for calibration. Removing the meters from the flow line would expose workers to process materials. To avoid exposure, calibrations were not performed. The net result was the plant didn't have valid sludge flow readings.

There were several negative business consequences of inaccurate sludge flow measurement. Chemical costs were increased to compensate for reduced biological activity. Operations costs increased due to the need to manually check material balances and adjust plant records. Personnel safety was at risk due to potential exposure to process materials. Finally, throughput was at risk due to lower biological activity in the sludge.

SMART Meter Verification reduces chemical cost and increases efficiency.

Figure 1. Rosemount 8732E Magnetic flowmeter with SMART Meter Verification.

ROSEMOUNT For more information: www.rosemount.com

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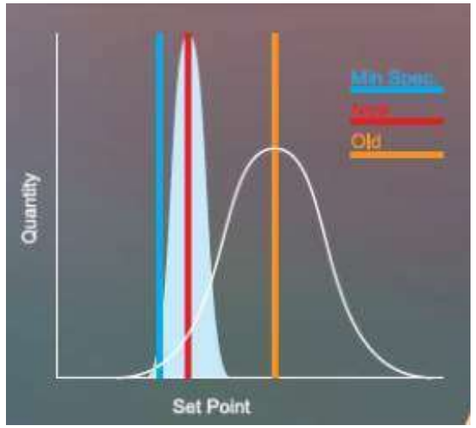
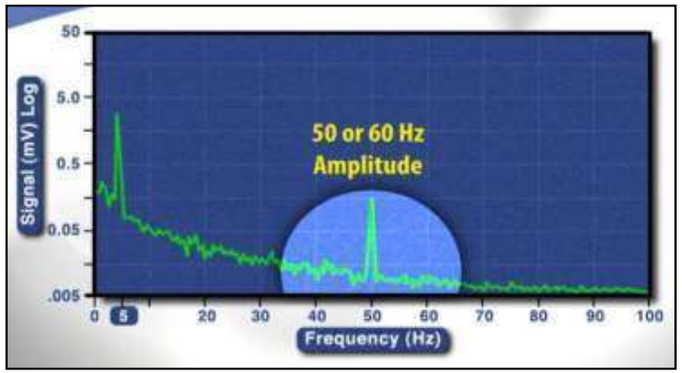
Universal™ Capabilities Extend Diagnostics to any Mag Installation

I would like to have diagnostic capabilities on my old installed base of magnetic flowmeters.

It would allow me to optimize my processes without requiring replacement of perfectly good sensors.





- Replacement of an existing installed base is expensive and impractical, especially when the sensor is still healthy
- Diagnostics not only work on Rosemount sensors they work on other manufacturers' sensors as well

Rosemount Mag
Universal Diagnostic™ Technology

- Universal Capabilities
  - Only Rosemount offers the functionality to drive tubes across a wide-ranging currents
    - Scalable from 0.075 to 0.5 amps
  - Can drive virtually any flow tube sensor from any manufacturers
    - Simple conversion of others k-factors to Rosemount calibration numbers
  - ***Diagnostics not only work on Rosemount flow tube sensors – they work on other manufacturers' sensors as well.***

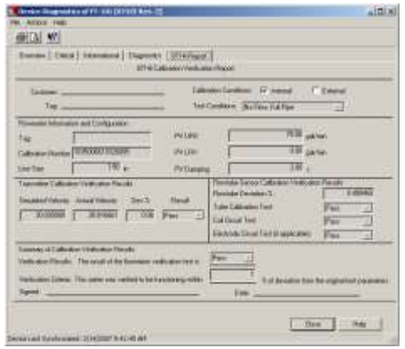
EMERSON

Universal Meter Verification improves installations with other manufacturers' sensors

Typical Meter Verification Capabilities of other Manufacturers

- Trip to field
- Technical knowledge and Extra equipment
- No formal report
- No deviation values
- More than 120 minutes

Rosemount Universal



- No Trip to field
- No Extra equipment, simple meter verification diagnostic
- Formal report
- Deviation values
- Approx 6 minutes

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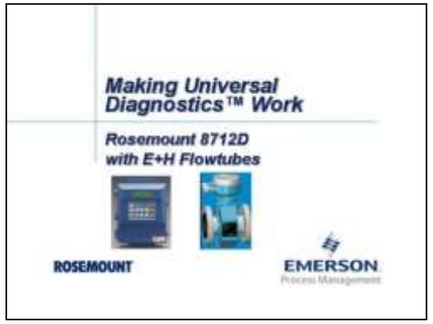
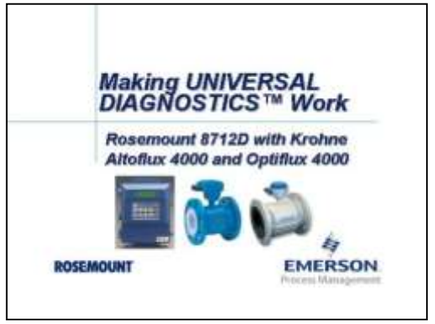
Universal Transmitters
- How do I make it work?

Making Universal Work is as easy as 1 - 2 - 3….

1. Review the application
   - Verify sensor is in working condition and will work with the Universal transmitter
2. Connect the Universal transmitter to the sensor
   - Wiring diagrams are provided in the reference manual
3. Determine the Universal Calibration Number
   - Calibration Number Prediction
   - Universal Auto Trim
   - Flow lab calibration

FAQ Documents:





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Determining Universal Calibration Numbers

- Universal calibration number calculation tool
  - Excel spreadsheet that converts sensor K-Factor to a Rosemount 16-digit calibration number
  - Available for:
    - Foxboro 2800
    - Krohne Optiflux 4000 and IFS 4000
    - Yokogawa Admag and Admag AXF
- Universal Auto-trim
  - Calibrates Universal transmitter to current flow reading
  - Requires a known flow rate
  - Best option when replacing a transmitter to get access to diagnostics
    - Simplifies In-Situ Calibration
- Send sensor to Rosemount for calibration
  - Can be supported, but not typically done as it requires removal of the sensor

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Universal Matters: Proven Results

Universal transmitter capabilities allowed this municipal treatment facility to improve quality and reduce maintenance costs

- Raw feed water
- Installed flow meter was giving an erratic output
- 30-inch sensor which could not be removed from process without shutting down the facility
- Universal transmitter capabilities allowed this user to continue operation and provided a stable output allowing the facility move to automatic control of chemical feeds
- 00830-0900-4727

Municipal Water Treatment Facility Increases Water Quality with Universal Transmitter Technology

RESULTS

- Improved water quality
- Avoided facility shutdown
- Reduced operations and maintenance costs

Stable and accurate measurement from the 8712D with Universal Auto Trim capability enabled the facility to automatically operate chemical feed volumes and improve water quality.

APPLICATION

Raw feed water measurement to water plant

CUSTOMER

Municipal water treatment facility in the United States

CHALLENGE

This municipal water treatment facility (over 40 million gallons per day capacity) had problems controlling the volume of treating chemicals to the raw water feeding the facility.

The previously installed magnetic flowmeter caused erratic flow measurement when it exceeded 50% of its flow range and resulted in incorrect volumes of feed chemical into the raw feed water supply. This reduced water quality caused facility operations personnel to operate the valves in manual and pay close attention to the chemical feeds. The customer considered removing the entire 30-in. (76.2 cm) magmeter sensor, which would involve shutting down the facility. This would have incurred significant repair costs, which include labor and a crane to remove the 20-ft. x 15-ft. (6.1 m x 4.5m) cover to a concrete vault and the 1800 lb. (847 kg.) sensor.

SOLUTION

The sensor was found to be in working condition through a resistance check. The previously installed transmitter was then replaced with the Rosemount 8712D with Universal Transmitter Technology. The plant operator manually stabilized the flow rate, which provided a baseline for the Universal Auto Trim feature included with Rosemount Universal Transmitter Technology. After a baseline measurement was found, the 8712D provided a stable and accurate measurement over the entire flow range of the sensor.

The Rosemount 8712 with Universal Transmitter Technology

ROSEMOUNT For more information: www.rosemount.com

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What's NEW? Sensor and Transmitter Migration from ES to EM

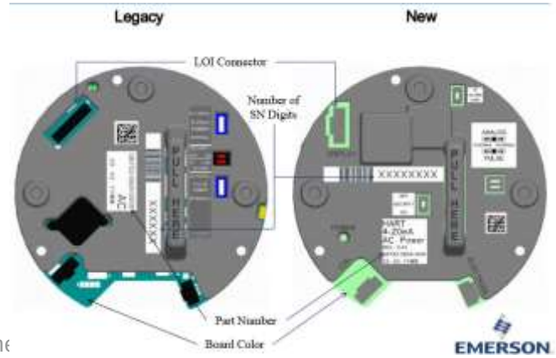
- Originally driven by new requirements for FM approval, but drove project to make other enhancements.
- Additional Diagnotstics

Standard	Process	Meter Health
Configurable Empty Pipe	Grounding / Wiring	Transmitter Verification
Coil Short	High Process Noise	Coil Circuit Health
Electrode Short	Electrode Coating Detection	Electrode Circuit Health
Coil Over Current		Sensor Verification
Electrode Saturation		Continuous Smart Meter Verification
Electronics Failure		

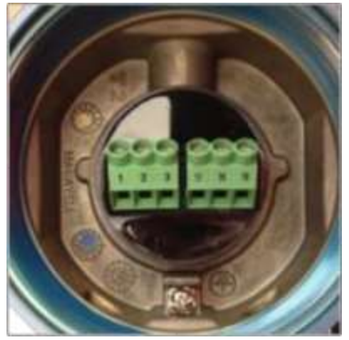
3-Build Paint System

- 3-build paint system
  - Base layer conversion coating improves material adhesion and prevents corrosive spread
  - Thick build epoxy mid-coat provides primary resistance to corrosion
  - Polyurethane top-coat provides UV and corrosion resistance
- Surpasses NEMA 4X Testing
  - Passed testing when subjected to 1500 hours of salt spray

- Improved LOI Design



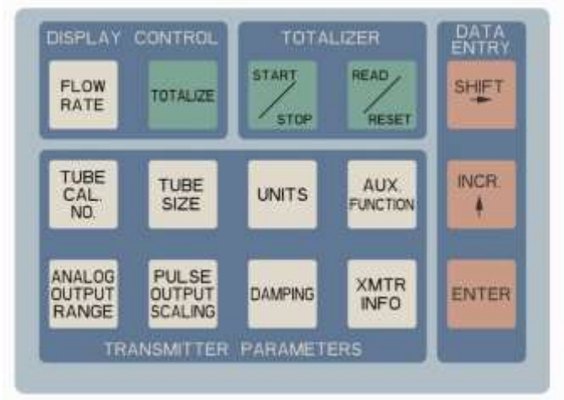
Field Replaceable Terminal Block (on some models)



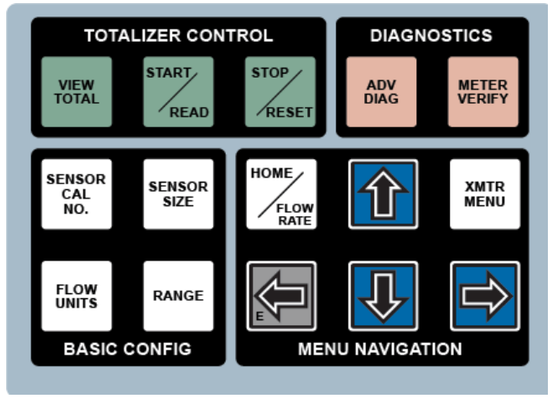
What does this change mean for you?

- Additional Diagnostic Features
- Enhancements to 8712 wall mount to match 8732 features
- MODEL CODES will be slightly different
  - Besides EM vs ES, the agency approval section of the model code may change
- When ordering parts or mixing platforms between sensor and transmitter, check with your local sales representative

8712ES



8712EM



For more information visit Midwest Municipal Instrumentation

Booths 1105-1106

Thank You

Any Questions?

Emerson Confidential

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