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Measurement of Partially filled Pipes in Collection Systems

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Measurement Techniques for partially filled pipes in Collection Systems:

Flumes

Area Velocity/ Laser and Radar devices

Electro Magnetic Flow Meter

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Measurement Techniques for partially filled pipes in Collection Systems:

- **Flumes**
- **Area Velocity/ Laser and Radar devices**
- **Electro Magnetic Flow Meter**

Flumes

Flumes and weirs are often used for flow measurement in collection systems

A constriction in a channel results in a liquid level which is representative of a flow rate.

Two flumes commonly found in collection systems are the Parshall and the Palmer Bowlus.

Parshall Flume

The Parshall flume, developed by Dr Ralph Parshall in 1915, is one of the most common flumes for open channel flow measurement

Parshall flumes come in throat widths of 1 inch to 12 feet with head heights of up to 3 feet

Palmer Bowlus Flume

The Palmer-Bowlus Flume is the result of the investigations started in the 1930s by two engineers of the Los Angeles County Sanitation Department, Harold Palmer and Fred Bowlus, into adapting Venturi flumes for use in sanitary sewers.

Palmer Bowlus Flume

Palmer Bowlus flumes were designed to measure in existing manhole channels and inline sewer piping.

Palmer Bowlus Flume

Palmer Bowlus flumes are available is sizes from 4 to 72 inches but are most seen in sizes up to 12 inches.

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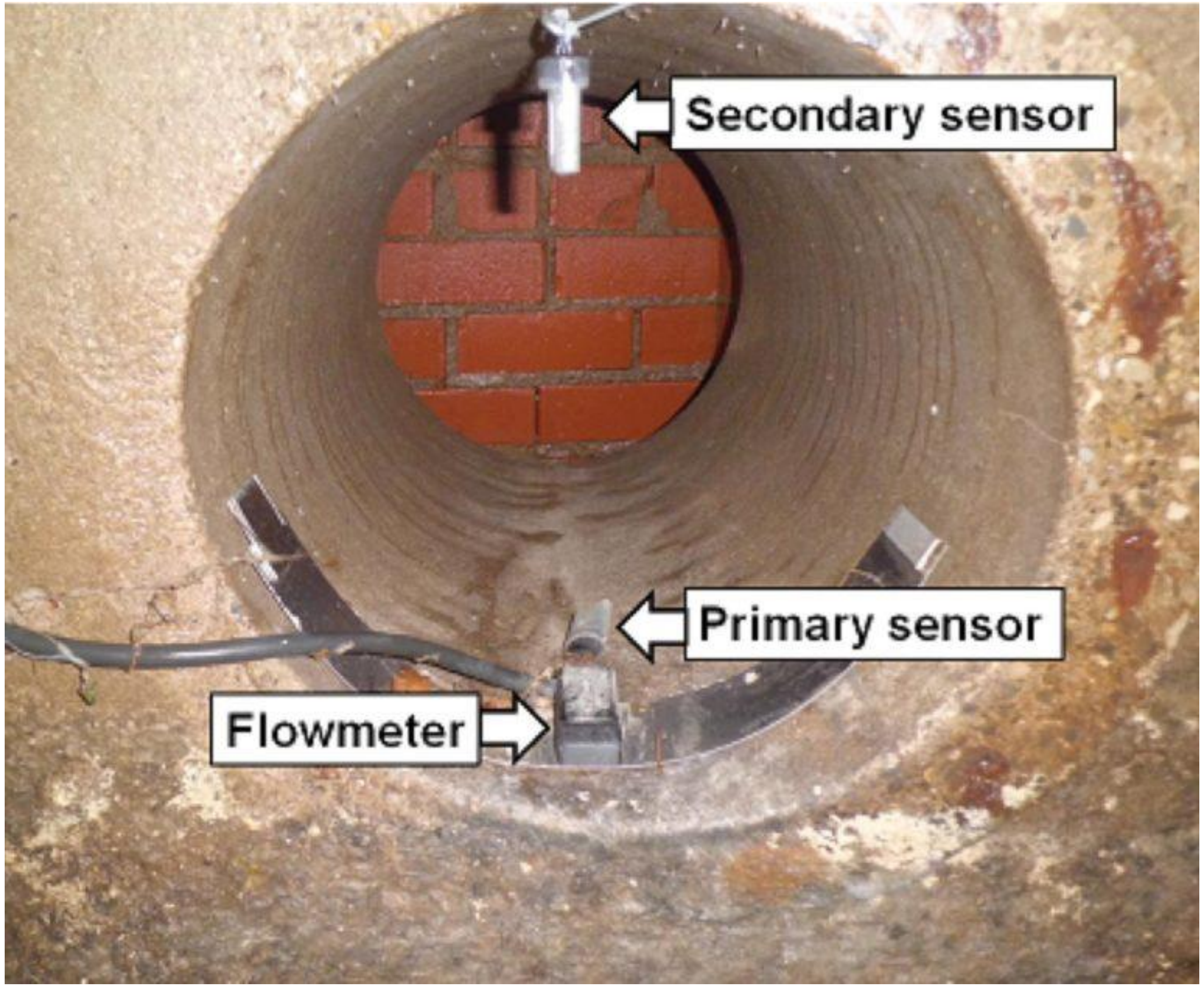
Measurement Techniques for partially filled pipes in Collection Systems:

- Flumes
- Area Velocity/ Laser and Radar devices
- Electro Magnetic Flow Meter

Area Velocity Flow Meter

An area-velocity meter is an open channel flow meter that measures flow by making two separate measurements one of depth (or height) and one of velocity.

The measurement can be made by a single integrated device or two devices.



Area Velocity Flow Meter

The depth is converted to cross sectional area using the geometry of the pipe or channel.

Area Velocity Flow Meter

The flow is computed by multiplying the volume of the cross-sectional area times the velocity.

AVFM above the flow

Measuring flow from above with area velocity meters is accomplished by utilizing laser or radar for velocity and ultrasonic or radar for level. These devices can be used in round pipes, oval pipes and other geometries.

If the measuring location becomes submerged options for a pressure measurement for level exist.

AVFM above the flow

Laser device

AVFM above the flow

Radar device

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Electro Magnetic Flow Meter

Electro Magnetic Flow Meter

EMF measurement is based upon Faradays law of induction.

Passing a conductor through a magnetic field will induce a voltage.

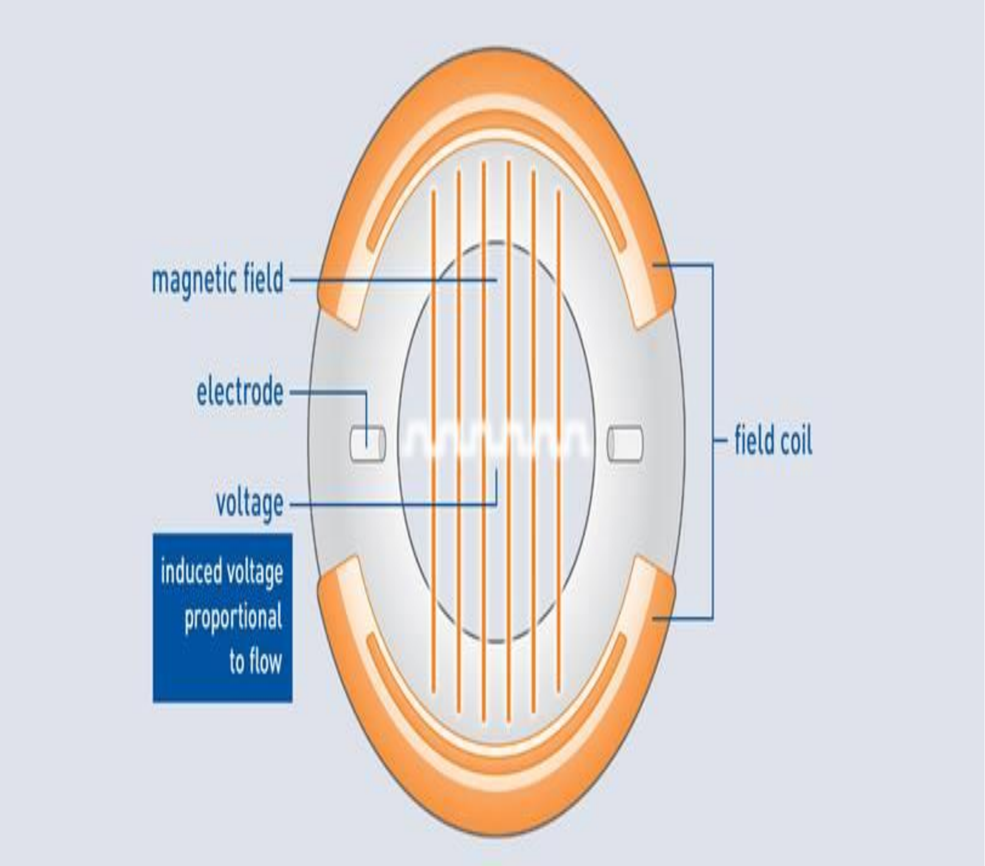
The induced voltage is directly proportional to the velocity of the conductor.

Electro Magnetic Flow Meter

A magnetic field is generated by pulsing coils surrounding a measuring tube

When an electrically conducting liquid flows through the magnetic field of an EMF a voltage is induced.

Electrodes mounted on either side of the measuring tube pick up the induced voltage.

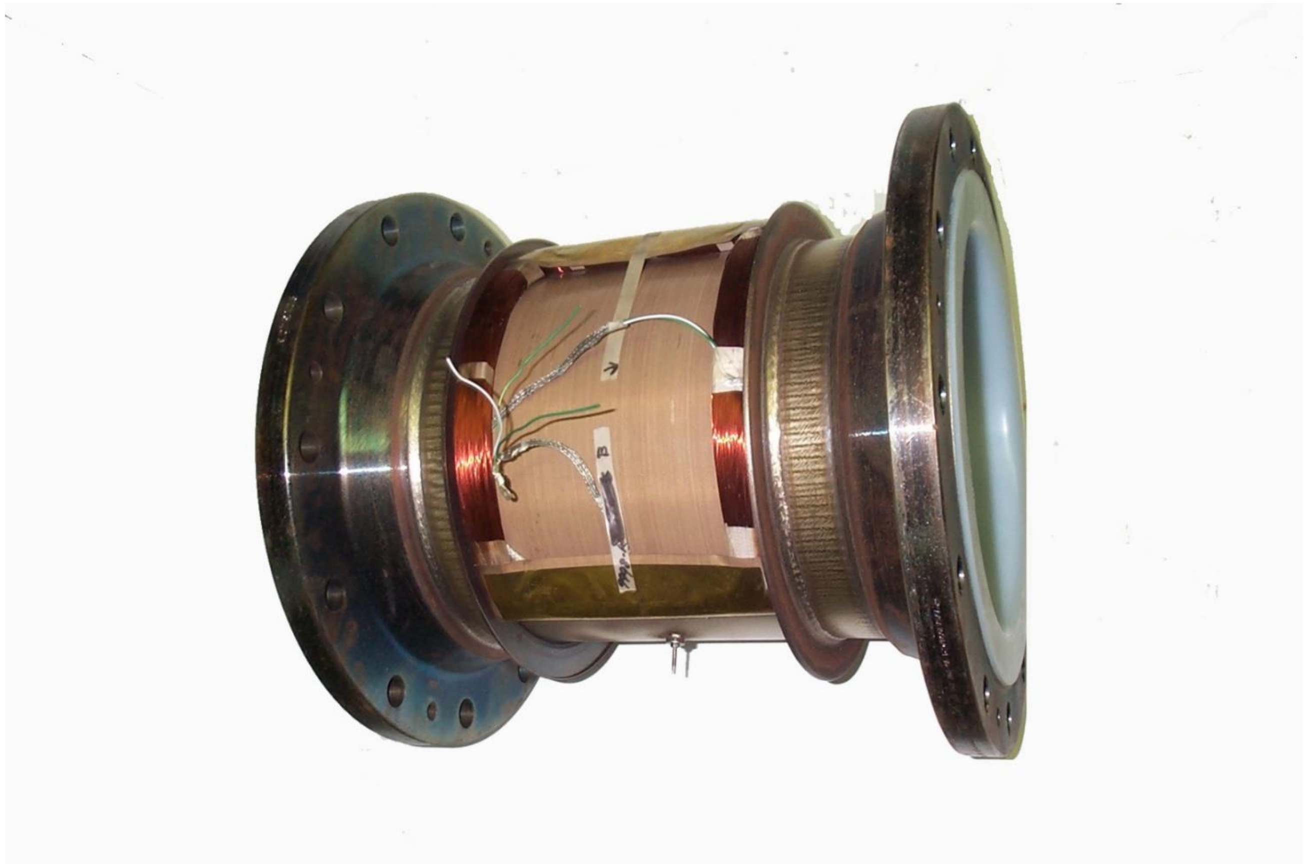


Electro Magnetic Flow Meter

The induced voltage is proportional to the flow velocity.

A traditional EMF measures velocity. The volumetric flow is calculated from the cross-sectional area multiplied by velocity.

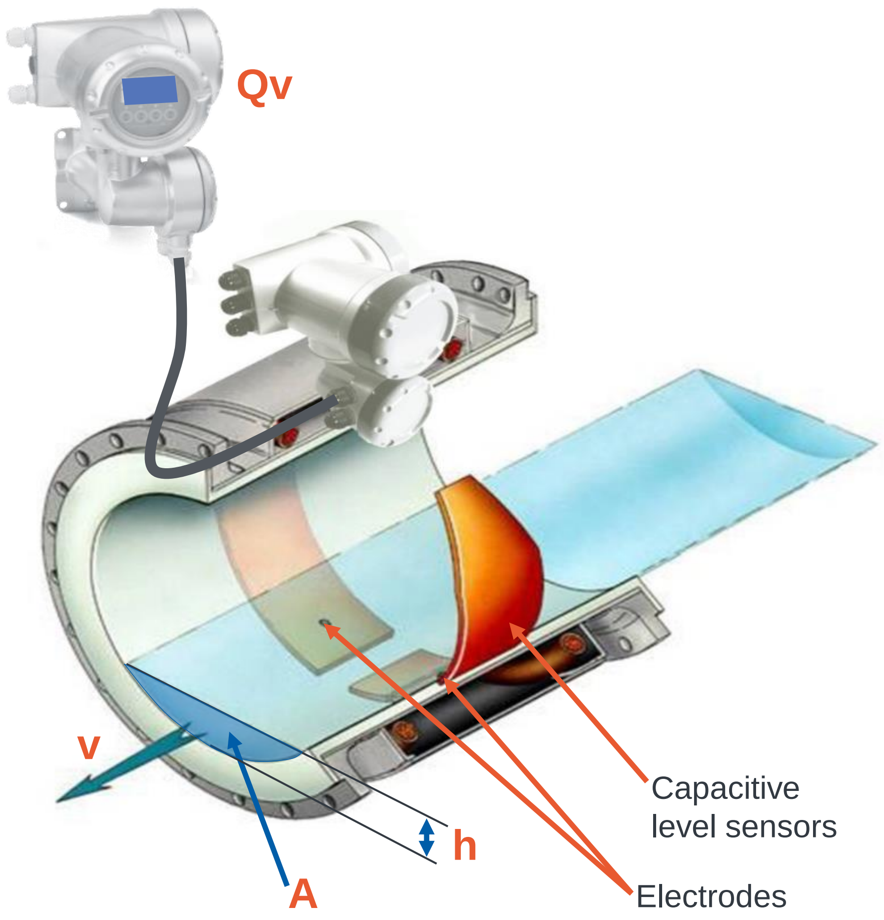
The tube is assumed to always be full



Partially Filled Electro Magnetic Flow Meter

Capacitive non-wetted level sensors measure filling level **h**

From filling level **h** the filled flow cross section, **A** is calculated



Partially Filled Electro Magnetic Flow Meter

Flow velocity is measured based on electromagnetic flow measurement principle.

The signal converter calculates the flow rate based on flow velocity and filled cross sectional area

Partially filled Meter Calibration

All flowmeters are wet-calibrated in the factory

The meter calibration factor is determined at full pipe

Static level calibration is performed at different conductivities from 50…5000 µS/cm

Dynamic flow calibration is performed from 10% up to 100% of full pipe for flow profile corrections

Calibration certificate included

A Closer Look At Accuracy

Measurement of Partially Filled Pipes in Collection Systems

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Accuracies Parshall

Under laboratory conditions, Parshall Flumes can be to be accurate to within +/-2%. However, practical considerations such as approach flow, installation, and dimensional tolerances result in free-flow accuracies of **+/-5%** (per ASTM D1941).

Correction tables exist for Parshall Flumes operating in submergence. Corrections begin at 50% submergence on smaller flumes and 65% submergence on larger flumes.

Submergence is the ratio of the downstream measurement (Hb) to the upstream measurement (Ha)

Accuracies Palmer Bowlus

The error of the Palmer-Bowlus Flume is +/-3-5% under normal operating conditions – where the head in the flume is large in comparison to the length of the throat. For lower flows, where the head is low compared to the length of the throat, the error increases to +/- 5-6%

Unlike the Parshall or Cutthroat Flumes, the are no corrections for Palmer-Bowlus Flumes that have settled (or been installed at a slope).

AVFM

A typical error statement for a wet sensor AVFM is **Level: +/-0.25% of Range, Velocity:- +/-2% of Reading**, the range can be as long as 4.4 meters

AVFM above the flow

One devices error statement is .5% +/- .01FPS on velocity and .24” of level under 1ft or .48” over 1 ft

Another devices error statement is .5% +/- .1FPS on velocity and 1% +/-.1” on level

Partially Filled EMF

The error statement for the partially filled magnetic flow meter is two parts

1. When filled the meter will have better than 1% of MV value.
2. When partially filled the meter will read better than 1% of the high velocity.

    The high velocity occurs at 80% of filled.

Accuracy

The error statements for all the devices appear similar, the partially filled EMF statement is a maximum error statement which includes both level and velocity measurement errors

The flume error statement does not include the level device measuring error. Errors of the level measuring device must be added to the flume error to obtain maximum error.

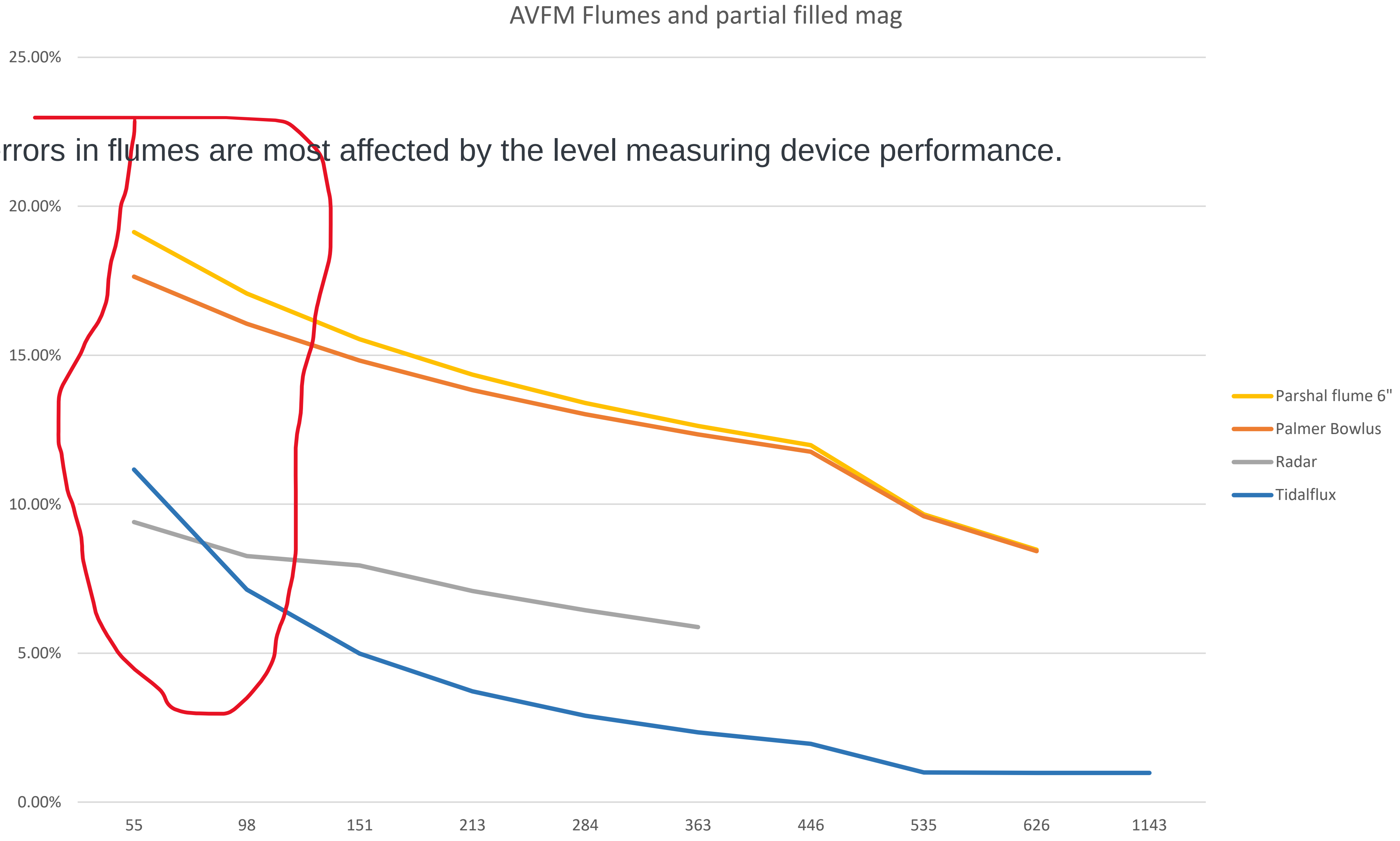
The “over the flow” AVFM also has a two-part error statement, one for level and one for velocity.

Accuracy

Using a 12 inch partially filled pipe/channel as the basis of measurement for the AVFM and the Magnetic flow meter, and comparing those to a 12-inch Palmer Bowlus and a 6-inch Parshall flume (dictated by flow rates) the error statements represented graphically would look like this:

AVFM, Flumes and Partially Filled EMF

Low flow errors in flumes are most affected by the level measuring device performance.



Closed pipe measurement advantages

Safety Concerns????

AVFM above the flow

Radar device

Dislodged after Surcharge

Parshall Flume

Parshall Flume in a surcharged collection system

Closed Pipe Measurement

Closed Pipe Measurement

No direct contact with Harmful gases (H2S)

Protects instruments in measuring area from corrosive gases

No fugitive emission to atmosphere

Closed pipe prevents I&I (in theory)

Closed pipe prevent Surcharge at the measurement point

Closed Pipe Measurement

Simple Installation

Retrofit in existing sewage systems

Simple straight pipework 5D up and 3D down straight runs

Bi-directional measurement: No problems with backflow

Burial installation (IP68) (special coating)

Easy to commission: No on-site calibration required

Advantage of closed pipe

Closed Pipe Measurement

Minimizes need for regular cleaning slightly smaller ID of meter increase Velocity preventing sediment drop out

Absence of internal moving parts

Smooth liner

- Prevents surface build-up of fat and other deposits

Capacitive level measurement integrated into the liner

- No direct contact with liquid

Closed Pipe Measurement

Perfect for gravity feed

Reduces pump capacity requirements

Saves energy costs

Closed Pipe Measurement

The meter liner must be compatible with the process

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Applications

Measurement of Partially Filled Pipes in Collection Systems

Closed Pipe Applications

Partially filled and gravity feed pipes

Combined & Separate Sewage Systems

Combined Sewer Overflows (CSOs)

Storm Water Overflows (SWOs)

Rainwater retention basins

Intake (influent) at wastewater treatment plants

Closed Pipe Applications

Stormwater Collection

Sewage Collection

Rainwater Overflow

Closed Pipe Applications

Schuylkill County PA

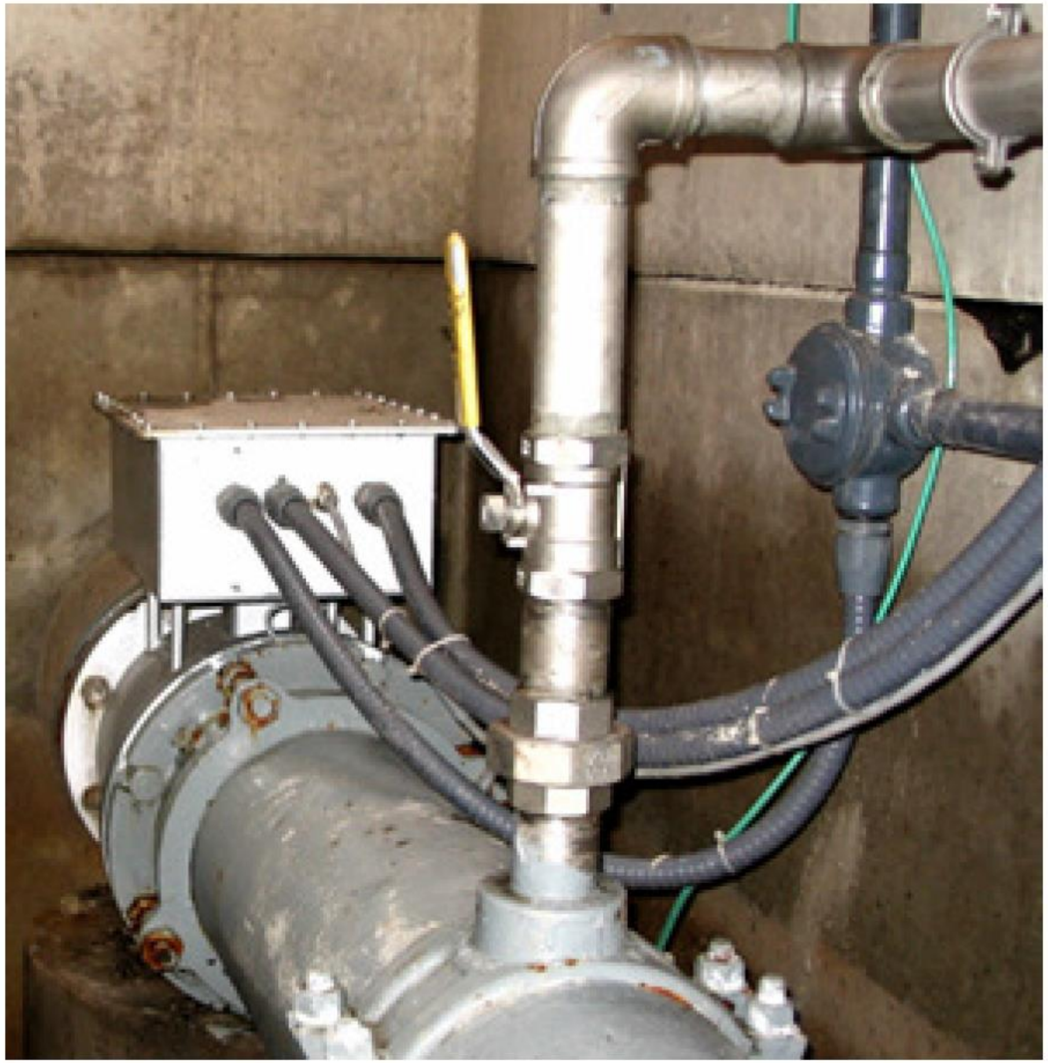
CSO Divergence

21 Meters from 8” to 20”

Used to divert high water away from plants

Plants suffered overflows/upsets and then fines

Plants have been operating without upsets and fines



Closed Pipe Applications

54-inch in collection system

Durham NC

Closed Pipe Applications

Two 36 – inch for installation

in a Wet Weather Collection system

Closed Pipe Applications

12”

Collection system

Red Deer, Alberta

Closed Pipe Applications

72 inch

Influent

Water Treatment plant

Appomattox VA

Closed Pipe Applications

24 - inch

Influent

Drinking water plant

Millsboro DE

Mostly submerged service

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Thank you for your attention!