American Water Works Association

Dedicated to the World's Most Important Resource®

CONTROLLING NON-REVENUE WATER IN DRINKING WATER UTILITIES

COURSE 2

ACCURATE METERING OF WATER PRODUCTION FLOWS

ACKNOWLEDGMENTS

Project Contractor

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COURSE LEARNING OBJECTIVES

As a result of this course, you will be able to:

Identify	water flows that are classified as production flows
Explain	the critical importance of accurate production flow data to the integrity of the AWWA water audit
Distinguish	between the primary types of production flowmeters used in drinking water supplies
Recall	the basic ways to test production flowmeter performance and calculate the accuracy rating from typical testing data
Explain	why production flowmeters are important assets that must be maintained, repaired, and replaced on a regular basis as part of good asset management
Tabulate and Analyze	production flowmeter data to observe flow trends and identify data errors and data gaps

Course 2
Accurate Metering of Water Production Flows

Course Agenda

Module Number	
1	The Critical Need for Accurate Production flow data
2	Effective management of water production flowmeters
3	Managing production flow data accurately
4	Course 2 Summary

MODULE 1

The Importance of Accurate Production Flow Data

Module 1 Agenda

A. Defining Production flows

B. The importance of accurate production flows

C. Standard types of flowmeters

Learning Objectives

As a result of this module participants should be able to:

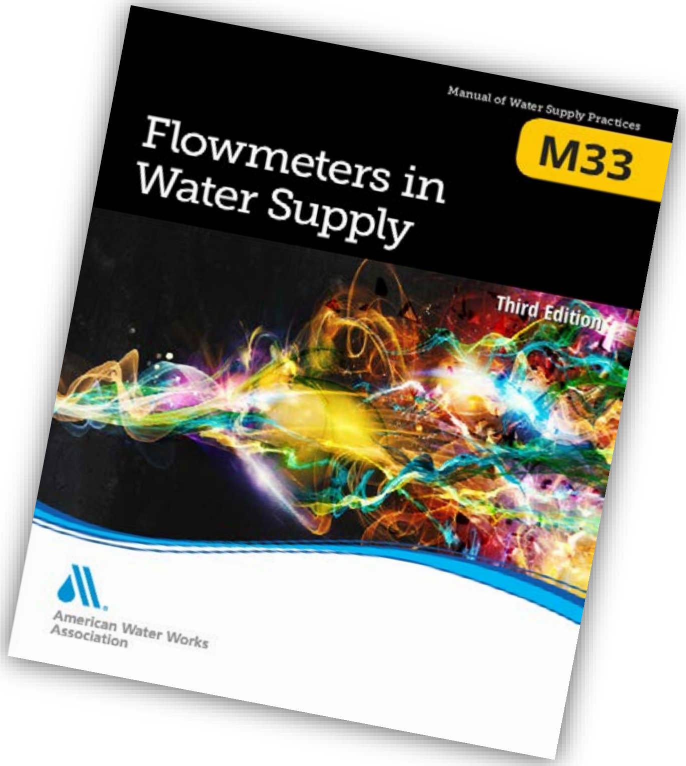
1. Distinguish "production" flows in a water system
2. Recognize the importance of accurate production flow data
3. Identify various types of meters and their applications

A. Defining Production Flows

8-inch turbine meter measuring flow to a system serving 1,000 people

The term *production* refers to the following types of metered water:

- Raw (untreated) water sources
- Finished (treated) water leaving the treatment plant and entering the water distribution system
- Bulk water imported (purchased) from another supplier
- Bulk water exported (sold) to another water supplier



Great guidance on selecting, installing and maintaining flowmeters

A. Defining Production Flows

Source water withdrawal volumes must be reported to regulatory agencies in the United States. Accurate flowmeters produce the data for this reporting

Metering raw (untreated) water flows

Many systems meter water only at the water source, including:

- Wells
- Rivers/streams/creeks
- Lakes
- Reservoirs/impoundments
- Decommissioned quarries

48-inch magnetic flowmeter being installed to measure raw water from the Schuylkill River in Philadelphia

A. Defining Production Flows

Metering Raw (untreated) Source Water

The AWWA Water Audit needs the volume of *treated* water supplied to the water distribution system.

Water Audit Report for:	Community Water Authority	
Audit Year:	2020	Jan 01 2020 - Dec 31 2020

WATER SUPPLIED

VOS	Volume from Own Sources:	n	g	4	12,088.980	MG/Yr
WI	Water Imported:	n	g			MG/Yr
WE	Water Exported:	n	g	6	2,012.456	MG/Yr
	WATER SUPPLIED:				9,702.921	MG/Yr

Volume from own Sources was measured by flowmeters metering "raw" or untreated water only

This is the volume of *treated* water that goes into the distribution system for the year and is usually slightly less than the volume of raw (*untreated*) water

A. Defining Production Flows

Water Supplied Error Adjustments

Scenario 1: flowmeters measure only raw (untreated) water at the source:

WATER SUPPLIED

						Water Supplied Error Adjustments				
						choose entry option:				
Volume from Own Sources:	n	g	4	12,088.980	MG/Yr	n	g	8	7.10%	percent
Water Imported:	n	g			MG/Yr					
Water Exported:	n	g	6	2,012.456	MG/Yr	n	g	9	0.50%	percent
WATER SUPPLIED:				9,264.994	MG/Yr					

The flowmeter error adjustment of 3.10% is combined with the adjustment for raw water consumed in the treatment process, (estimated at 4.00%), giving 3.10% + 4.00% = 7.10%

Scenario 2: flowmeters measure treated leaving a water treatment plant

WATER SUPPLIED

						Water Supplied Error Adjustments						
						choose entry option:						
Volume from Own Sources:	n	g	4	12,088.980	MG/Yr	n	g	8	3.10%	percent	over-registration	VOSEA
Water Imported:	n	g			MG/Yr							WIEA
Water Exported:	n	g	6	2,012.456	MG/Yr	n	g	9	0.50%	percent	under-registration	WEEA
WATER SUPPLIED:				9,702.921	MG/Yr							

Community Water Authority flowmeters measure treated water and over-register by 3.10%.

A. Defining Production Flows

Metering Treated, or Finished, Water

- The “Water Supplied Volume” in the AWWA Water Audit is treated water
- Metering the water supply at the point of treatment
- ***Treated water flowmeters are critical assets!***

Old 1.5-inch turbine meter measuring treated water from a well in a system serving 1,100 people

A. Defining Production Flows

Metering Imported (purchased) and Exported (sold) Water

- **Imported water**: usually the supplier selling the water owns/maintains the flowmeter
- Imported water is expensive; accurate metering is critical
  - *over-registering flowmeters mean that you are being over-billed*
- **Exported water**: this generates revenue, accurate metering is critical
  - *under-registering flowmeter means revenue loss*
- Include accuracy testing in the contract for service

12-inch venturi flowmeter measuring imported water

Flowmeter on exported supply

A. Defining Production Flows - using the AWWA Free Water Audit Software

WORKSHEET – WATER SUPPLIED SECTION

Volume from own Sources **+/- Volume from own Sources Water Supplied Error Adjustment**

+

Water Imported **+/- Water Imported Water Supplied Error Adjustment**

-

Water Exported **+/- Water Exported Water Supplied Error Adjustment**

= Water Supplied Volume

WATER SUPPLIED						Water Supplied Error Adjustments choose entry option:						
Volume from Own Sources:	n	g	4	12,088.980	MG/Yr	n	g	8	3.10%	percent	over-registration	VOSEA
Water Imported:	n	g			MG/Yr							WIEA
Water Exported:	n	g	6	2,012.456	MG/Yr	n	g	9	0.50%	percent	under-registration	WEEA
WATER SUPPLIED:				9,702.921	MG/Yr							

A. Defining Production Flows – KNOWLEDGE CHECK

Place a check in the box to the left of those flows that are measured by production flowmeters

Check Indicator below	Water flows
	Water exported
	Chemical process water
	Raw (untreated) water
	Filter backwash water
	Water imported
	Finished (treated) water

A. Defining Production Flows – KNOWLEDGE CHECK

Place a check in the box to the left of those flows that are measured by production flowmeters

Check Indicator below	Water flows
√	Water exported
	Chemical process water
√	Raw (untreated) water
	Filter backwash water
√	Water imported
√	Finished (treated) water

A. Defining Production Flows – KNOWLEDGE CHECK

Below are production flows from a small water utility. Calculate the volume of water supplied and select from the choices to the right. Use the equation given at the bottom of this slide.

Volume from own sources: 131.830 MG Water Imported: 0.278 MG Water Exported: 7.835 MG

Equation

Volume from own Sources +/- Volume from own Sources Water Supplied Error Adjustment

plus

Water Imported +/- Water Imported Water Supplied Error Adjustment

minus

Water Exported +/- Water Exported Water Supplied Error Adjustment

---

equals **Water Supplied Volume**

Select the correct answer from below:

a. 139.943 MG

b. 129.897 MG

c. 123.717 MG

d. 124.273 MG

A. Defining Production Flows – KNOWLEDGE CHECK

Below are production flows from a small water utility. Calculate the volume of water supplied and select from the choices to the right. Use the equation given at the bottom of this slide.

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Water Exported +/- Water Exported Water Supplied Error Adjustment

---

= Water Supplied Volume

Select the correct answer from below:

a. 139.943 MG

b. 129.897 MG

c. 123.717 MG

d. 124.273 MG

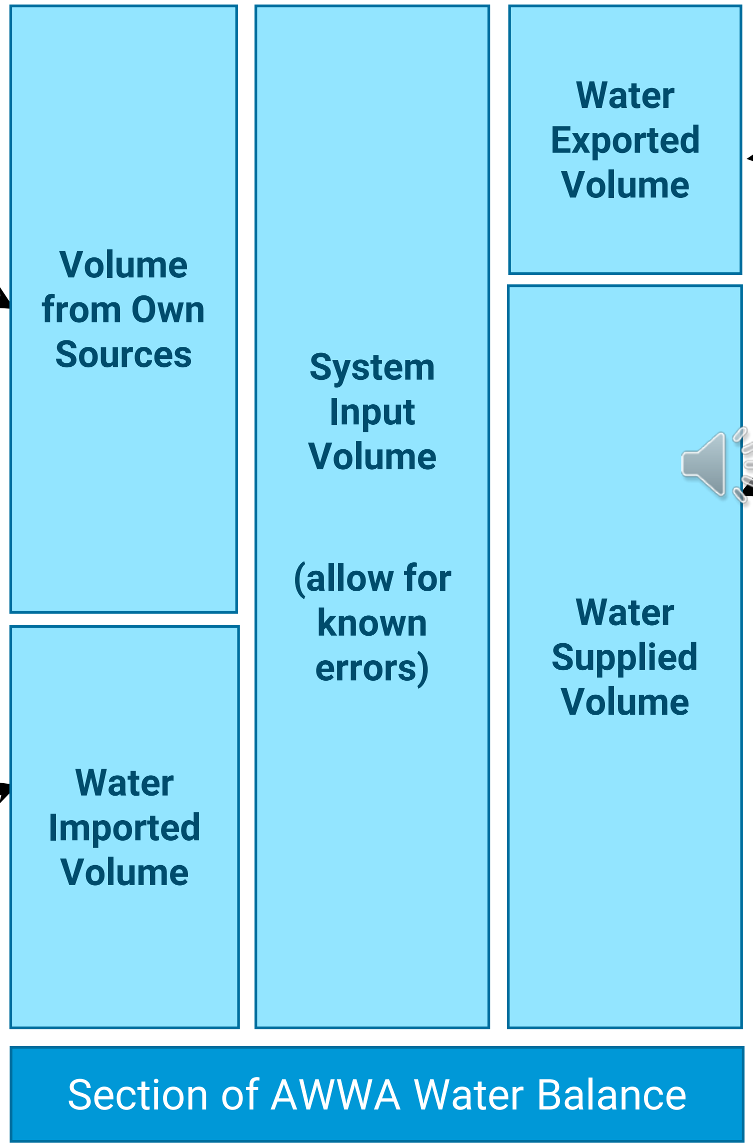
B. The importance of accurate production flows

Treated Water Meters

Production Meters

Wholesale Water meters

(water you purchased from your neighboring water system)



Wholesale Water meters

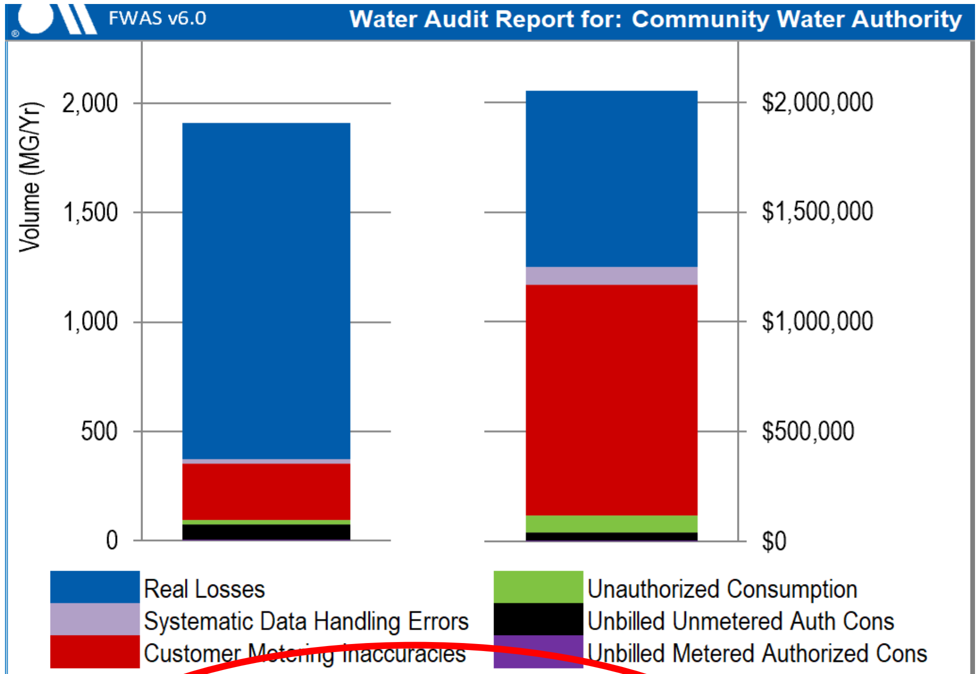
(neighboring water systems you sold to)

Annual Finished Water delivered to the Distribution System

Production flow data is critical to the AWWA water audit because they are:

- The first flow data input into the water audit
- The highest flow volumes in the water audit
- Usually measured by the largest meters in the utility
- Reported to regulatory agencies

B. The importance of accurate production flows



	Volume MG/Yr	Value $/Yr	Basis of Valuation
Apparent Losses	296.7	$1,210,051	CRUC
Real Losses	1,537.2	$801,241	VPC
Unbilled Authorized Cons	75.8	$39,494	VPC
Non-Revenue Water	1,909.6	$2,050,786	Blended

Depends on how you start the water audit!

WATER SUPPLIED

Water Supplied Error Adjustments

choose entry option:

Volume from Own Sources:	n	g	4	12,088.980	MG/Yr	n	g	8	3.10% percent	over-registration	VOSEA
Water Imported:	n	g			MG/Yr						WIEA
Water Exported:	n	g	6	2,012.456	MG/Yr	n	g	9	0.50% percent	under-registration	WEEA

WATER SUPPLIED: 9,702.921 MG/Yr

How you finish the water audit……….

B. The Importance of accurate production flows: KNOWLEDGE CHECK

Production flow data is critical to assess a water utility's Non-revenue water because?

a. Production flows are the first data input into the water audit
b. Production flows are the highest flow volumes in the water audit
c. Production flows are usually measured by the largest meters in the water utility
d. All of the above

B. The Importance of accurate production flows: KNOWLEDGE CHECK

Production flow data is critical to assess a water utility's Non-revenue water because?

a. Production flows are the first data input into the water audit
b. Production flows are the highest flow volumes in the water audit
c. Production flows are usually measured by the largest meters in the water utility
d. All of the above

C. Standard types of flowmeters

Meters used in ***high*** flowrate applications

- Venturi meters
- Orifice meters
- Magnetic meters
- Ultrasonic meters

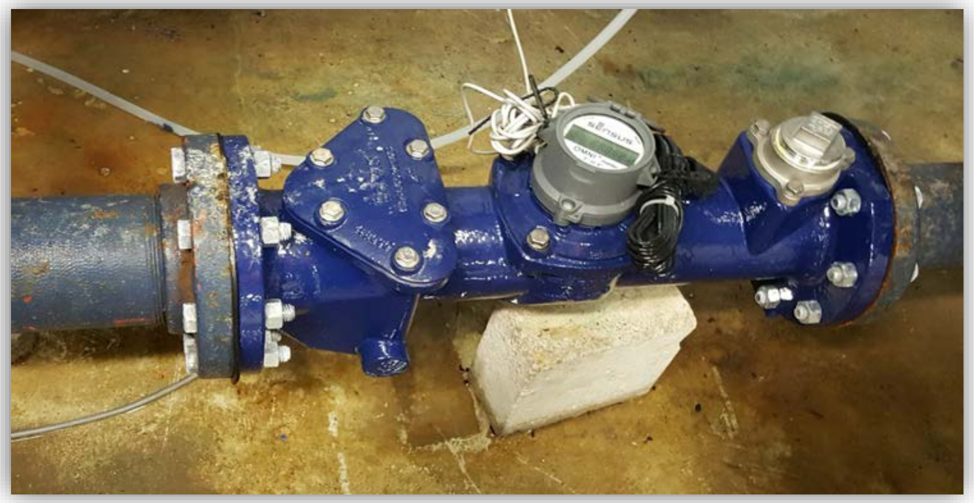
A 24-inch venturi flowmeter serving a community of 18,000 people

Transit Time ultrasonic meter with strap-on transducers on the pipe exterior

C. Standard types of flowmeters

Meters used in ***medium to low*** flowrate applications

- Turbine meters
- Propeller meters
- Positive displacement meters
- Magnetic meters
- Ultrasonic meters



A 4-inch horizontal turbine meter measuring flow from a well

Positive displacement meter

C. Standard types of flowmeters

Flowmeters can be:

- **Full-bore: installed as part of the pipeline**
  - Piping must be shut-off to remove the meter for repair or replacement
- **Portable**
  - Insertion or Strap-on

Different operating principles, including:

Head-Type Velocity meters

Volumetric meters

Linear Velocity or Inferential meters

Full-bore 2-inch positive displacement meter

Insertion magnetic flowmeter on a 30-inch pipeline

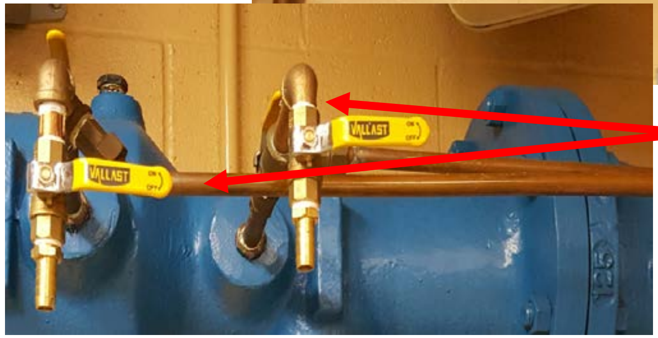
C. Standard types of flowmeters

Head-Type Velocity Meters

- Venturi flowmeter
- Orifice plate flowmeter
- Elbow flowmeter
- Pitot tube (insertion meter)

Venturi: may not work well with high turbidity raw water since particles can clog the sensing lines

An 8-inch venturi meter



<u>Pressure sensing lines</u>: Pressure drops as flow moves through the throat of the meter. The pressure drop is proportional to the velocity of flow in the pipeline.

C. Standard types of flowmeters

Volumetric Meters

Positive Displacement meters

- Nutating Disc meter
- Oscillating Piston meter
- Diaphragm meter

A 5/8-inch positive displacement meter and the nutating disc shown in two positions of rotation

C. Standard types of flowmeters

Linear Velocity or Inferential Meters

- Turbine meters
- Propeller meters
- Static meters (no moving parts)
  - Magnetic meters
  - Ultrasonic meters
- Multi-jet meters
- Single-jet meters

A 10-inch horizontal turbine meter measuring exported water leaving a water utility. Traditional mechanical turbine meters do not measure low flows accurately. A flowrate under 30 gpm may not be registered by this 10-inch meter.

C. Standard types of flowmeters

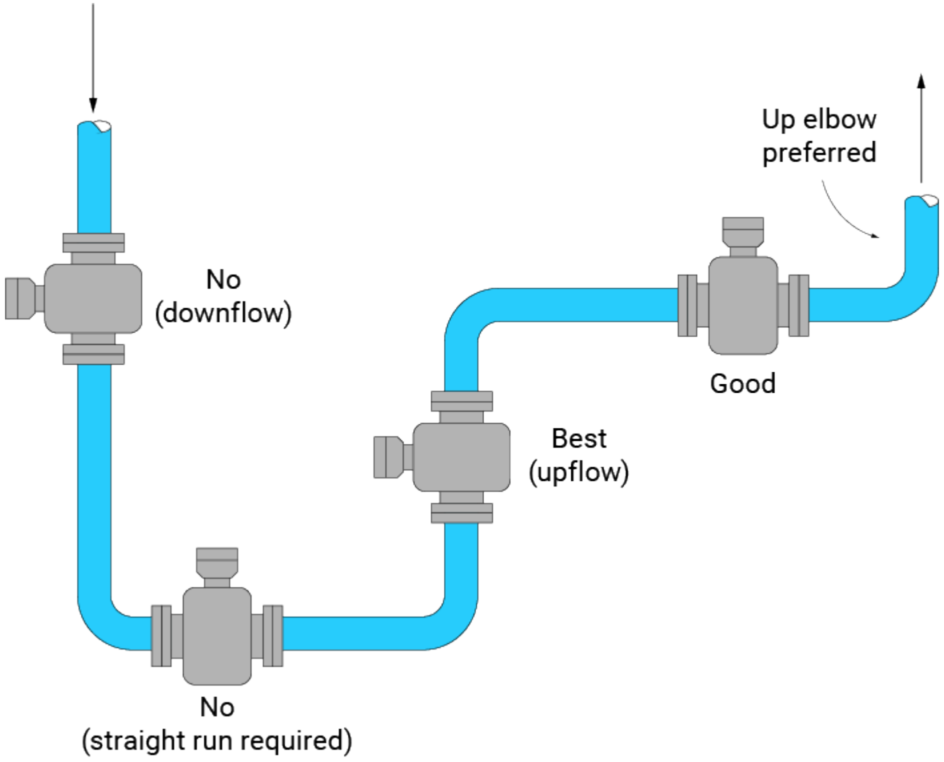
Static Meters (magnetic meters, ultrasonic meters)

- No moving parts
- Can be full-bore or portable
- Requires electric power (power supply or batteries)
- Historically used as production flowmeters but becoming commonplace in customer applications

A "magmeter" measuring flow leaving a water treatment plant

Magnetic Meters – Expected Battery Life		
Bore	Integral	Remote
5/8", ¾"	20 years	
1.5" – 3"	10 years	7 years
4" – 8"	7 years	5 years
10" – 24"	4 years	3 years
> 24"	2 years	2 years

C. Standard types of flowmeters



Electro-magnetic Meters

- Require a full pipe of water
- Use caution when installing on pipelines discharging water to an open tank or reservoir
- Meter installation alignment:
  - Horizontal: acceptable
  - Vertical: acceptable if flow is moving up, poor if flow is moving downward.
- Unobstructed pipe needed: at least five diameters upstream and two diameters downstream

- Best to have grounding for mag meters, especially larger meters
- Mag meters can be impaired by
  - placing a magnet near the mag meter
  - stray current

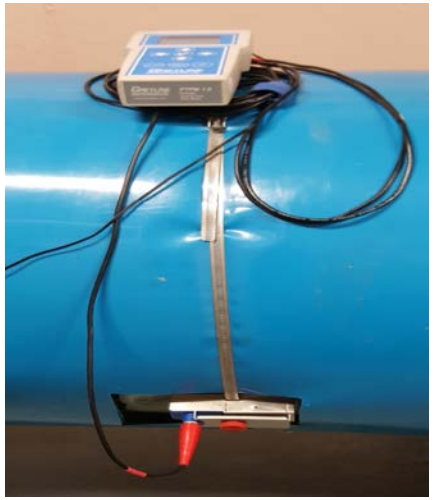
C. Standard types of flowmeters

Ultrasonic Meters

- Full bore - Transducer strap-on permanent - Strap-on portable

Full bore ultrasonic meter

Strap-on ultrasonic flowmeter installed permanently
Source: Frontier Precision



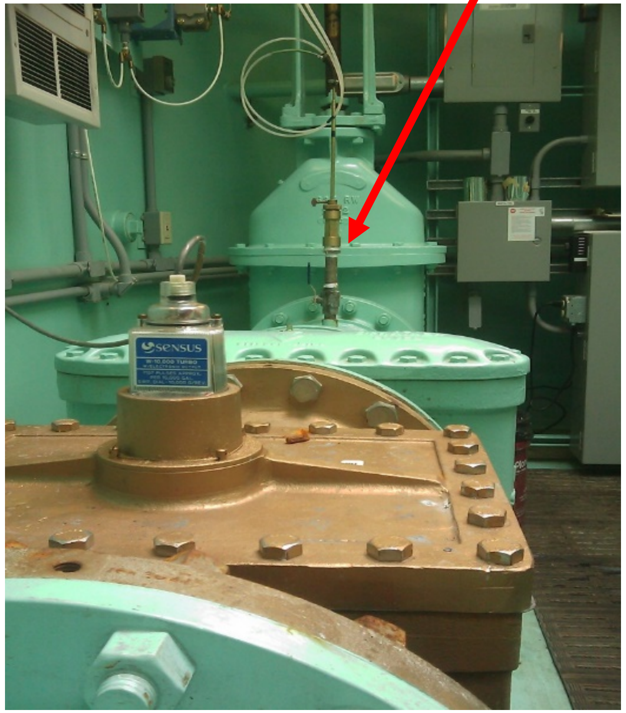
Strap-on ultrasonic flowmeter for portable use

C. Standard types of flowmeters

Insertion pitot rod

Insertion Meters

- A metering device that can be inserted into an in-service pipeline to measure the flowrate at that location
- Can be inserted into a one-inch tap and installed under pressure
- Less expensive and less intrusive way to measure flow
- Good to use for testing permanently installed flowmeters



16-inch turbine meter on wholesale water supply pipeline being verified via inline pitot rod

C. Standard types of flowmeters: KNOWLEDGE CHECK

The two primary types of portable meters that can be used to test permanent meters are:

a. Head-type velocity meters and volumetric meters

b. Insertion meters and strap-on meters

c. Static and full-bore

d. Venturi flowmeters and orifice plate flowmeters

C. Standard types of flowmeters: KNOWLEDGE CHECK

The two primary types of portable meters that can be used to test permanent meters are:

a. Head-type velocity meters and volumetric meters
b. Insertion meters and strap-on meters
c. Static and full-bore
d. Venturi flowmeters and orifice plate flowmeters

C. Standard types of flowmeters: KNOWLEDGE CHECK

Which of the below characteristics of static meters is not true?

a. Manufactured as full-bore and portable meters
b. Require electric power, either hard-wired or batteries
c. Include electro-magnetic and ultrasonic meters
d. Have moving parts that measure the flow of water

C. Standard types of flowmeters: KNOWLEDGE CHECK

Which of the below characteristics of static meters is not true?

a. Manufactured as full-bore and portable meters
b. Require electric power, either hard-wired or batteries
c. Include electro-magnetic and ultrasonic meters
d. Have moving parts that measure the flow of water

Module 1 Summary

We reviewed how production flows are defined in water utility operations

We explained why strong accuracy of production flowrates is important

Many types of meters can be used to measure production flows – picking the right meter for the right application is critical

MODULE 2

Effective Management of Water Production Flowmeters

Module 2 Agenda

A. Flowmeter Siting

B. Flowmeter Accuracy Testing

C. Flowmeter Replacement

Learning Objectives

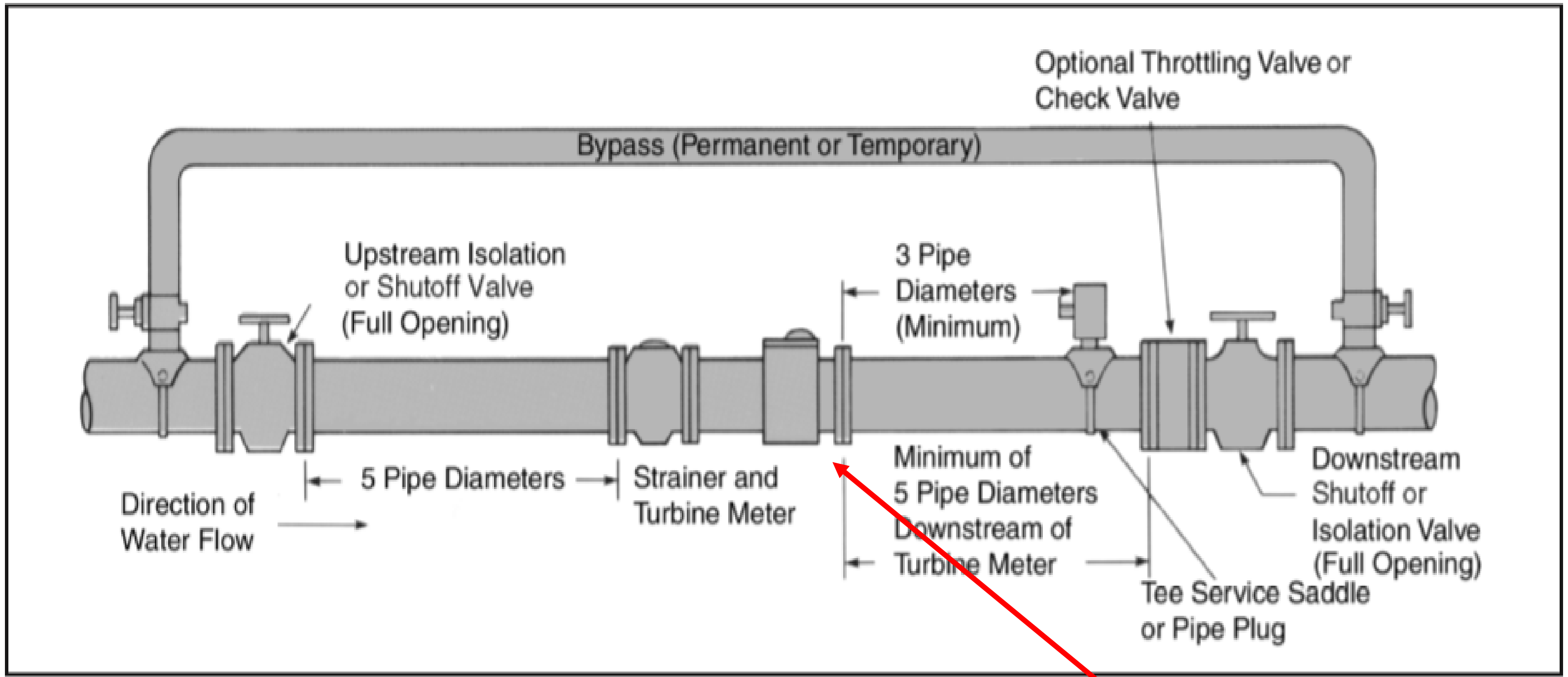
As a result of this module participants should be able to:

1. Properly select and site production flowmeters
2. Arrange for accuracy testing of flowmeters and interpret the results
3. Provide good upkeep for flowmeters

Flowmeter Siting

- Keep good information on all flowmeter installations, including:
  - Flowmeter size, type, year installed, and manufacturer
  - Piping features/configuration/limitations including bends, valves, strainers, backflow preventors, etc. (Take photos!)
  - Secondary instrumentation: differential pressure transmitters, etc.
  - Maintenance, testing, and repair information
- Search for this information if it is lacking

A. Flowmeter Siting



Example of a good meter "set" for a turbine meter

Source: AWWA M6 publication *Water Meters: Selection, Installation, Testing and Maintenance*

The Meter "Set"

- The configuration of the meter, piping, and fixtures

Good Practices

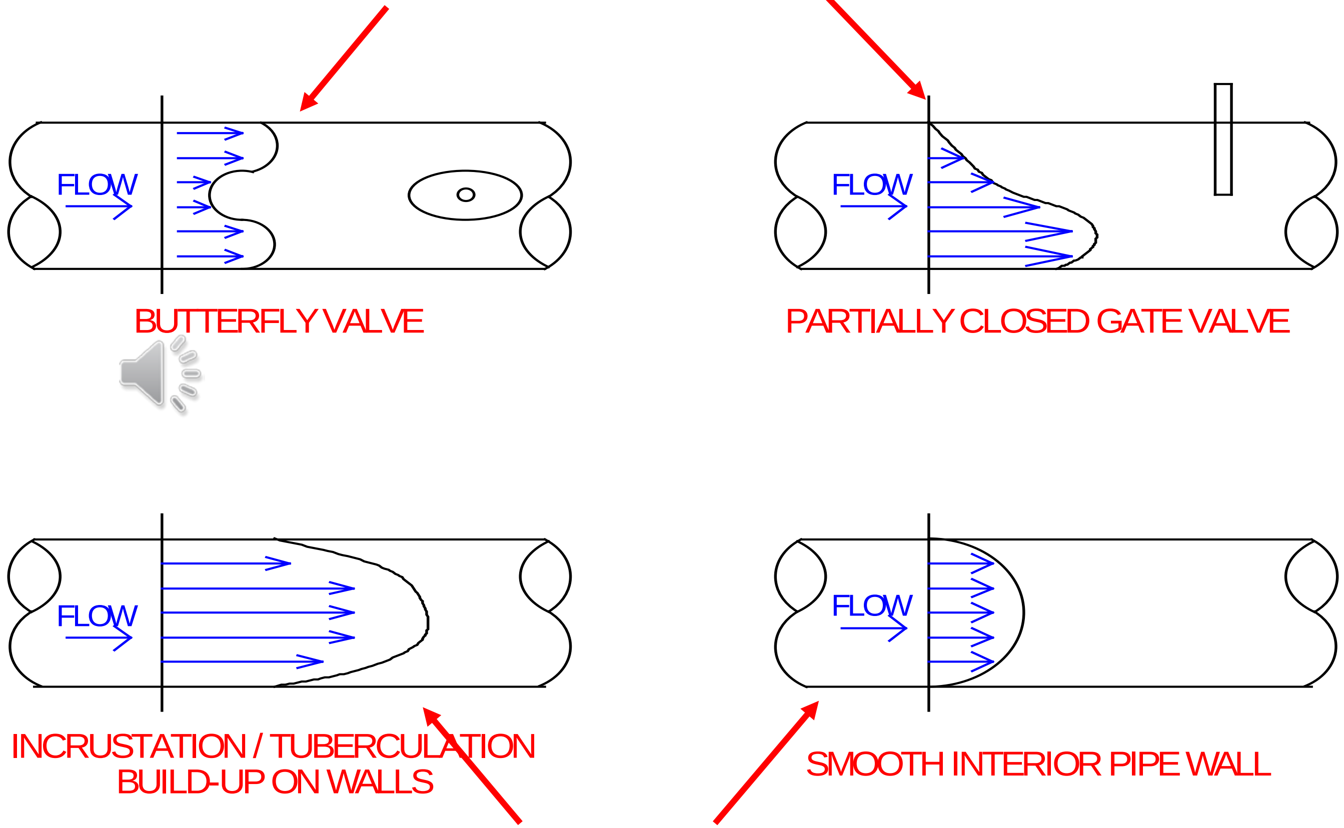
- Unobstructed spacing upstream and downstream of the meter
- Not close to pipe bends
- Isolation valves that are normally kept fully open
- Upstream strainer as needed to straighten the velocity profile

A. Flowmeter Siting

The Velocity Profile in a Pipe

- Measuring velocity in the pipe at different locations plots as a “profile”
- Best profile: maximum velocity in center, best to measure here
- Obstructions close to a flowmeter cause a distorted velocity profile
- Friction forces along the pipe wall slow the flow often giving the bullet-shaped velocity profile at bottom left.
- Good design minimizes the occurrence of distorted flow profiles

Skewed velocity profiles compromise good flow measurement



Good velocity profiles

A. Flowmeter Siting

Flowmeter Type	Recommended Lengths of Straight Pipe* (stated in terms of number of upstream pipe diameters for the given metering application)
Venturi	4–10 diameters—depending on the type of any flow-disturbing obstruction in the pipeline
Orifice	5 diameters
Flow tube	4–10 diameters—depending on the type of any flow-disturbing obstruction in the pipeline
Pitot tube	10 diameters
Propeller	5 diameters
Turbine	10 diameters—assuming a flow-straightening element is used (25 to 30 pipe diameters otherwise)
Magnetic	5 diameters
Ultrasonic (Doppler shift)	7–10 diameters
Ultrasonic (pulse transmission†)	7–10 diameters (and 5 diameters downstream)

- Allow for sufficient upstream (and downstream) distance to provide for a smooth flow profile
- Flowmeter considerations should be a primary part of the design process – not a secondary consideration left to chance of the installer

*Information is based on engineering judgment and conservative best practice observed in the water industry by AWWA Water Loss Control Committee members (M36 manual, 4th Ed)

†Includes transit time flowmeters

A. Flowmeter Siting

- Flowmeters often exist in cramped spaces with obstructions close to the flowmeter
- Good design avoids obstructions and pipe bends close to the flowmeter
- Don’t create an obstruction by throttling closed a valve in line with the flowmeter
- Most flowmeters are best installed in a horizontal and upright position

6-inch turbine meter installed in the vertical position

Venturi meter with valve in the throat

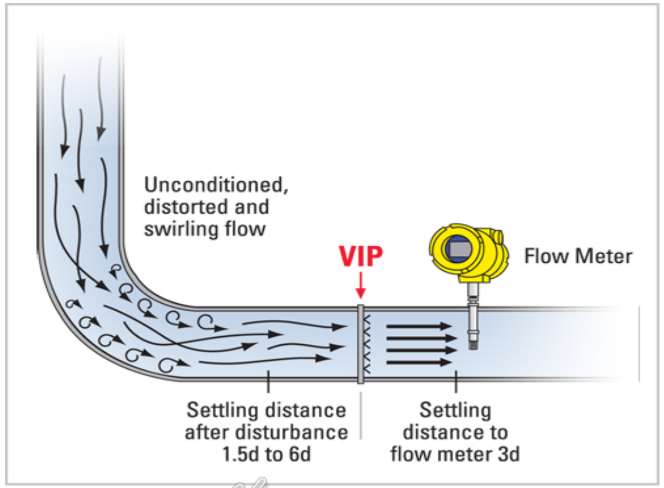
Mostly closed butterfly valve next to a flowmeter used to control flow to 144 gpm, but serves as an obstruction

Maze of pipe bends downstream of the above flowmeter

A. Flowmeter Siting

Flow Conditioning

- Meters need conditioned flow
- Site issues come into play such as straight runs of pipe, concrete pipe, valves, tees, elbows…
- Flow conditioners straighten flow
- Strainers restrict sediment and particles from passing through the flowmeter but also provide some flow straightening capability

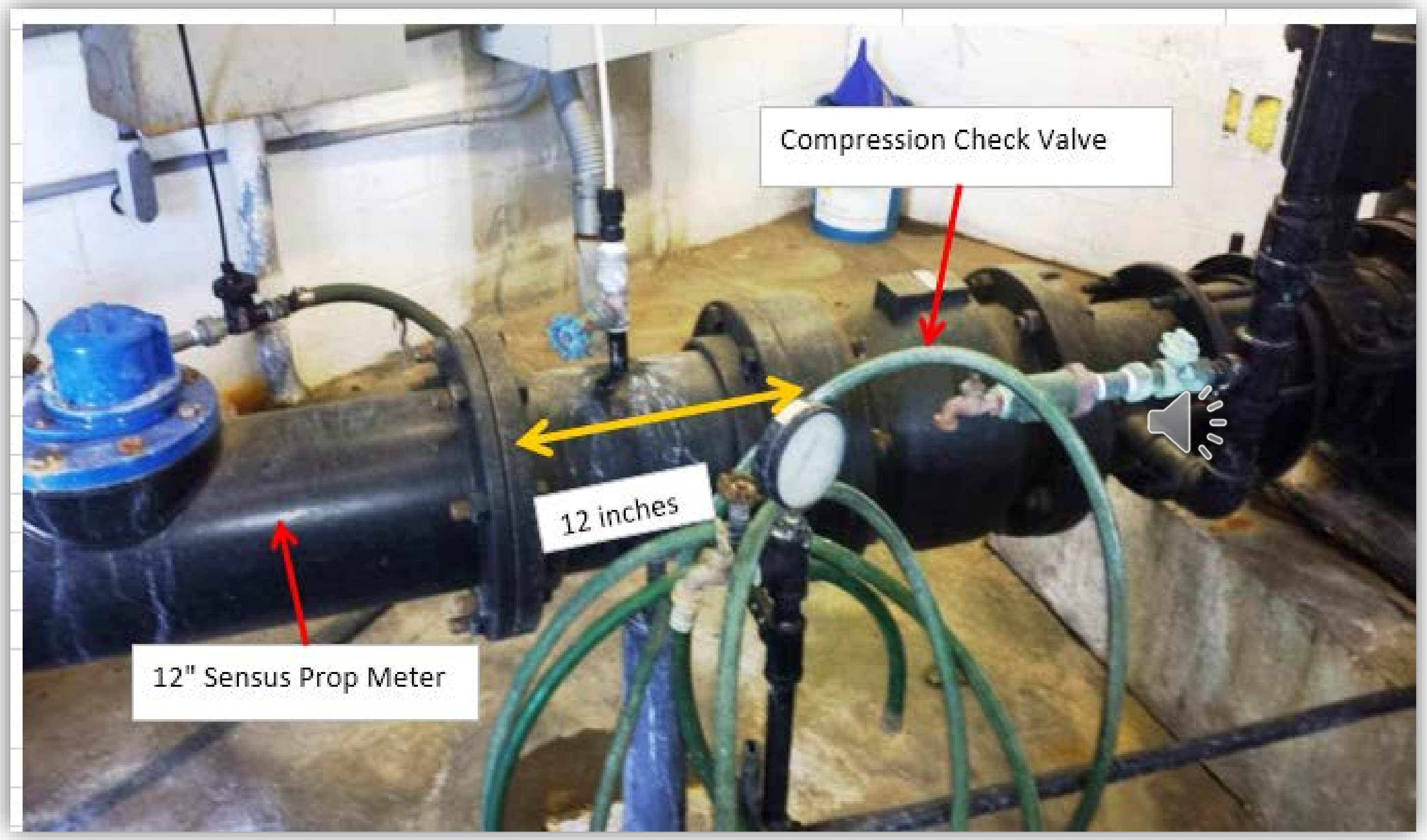


Source: Vortab Flow Conditioners

Insertion Panel Flow Conditioner
Source: Vortab Flow Conditioners

Strainer
Source: Neptune Technology Group

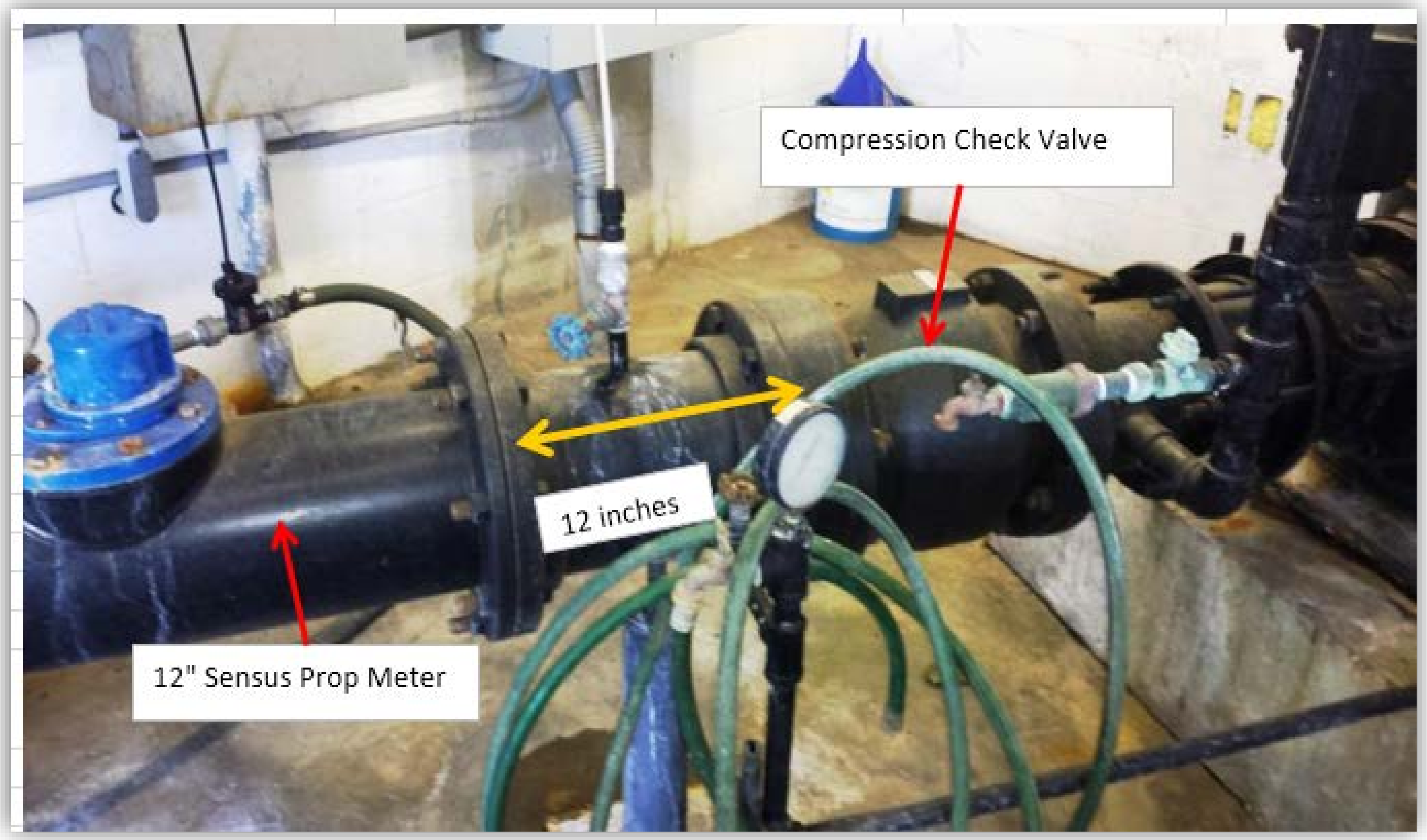
B. Flowmeter siting – KNOWLEDGE CHECK



What feature shown in the photo might distort the velocity profile through the propeller flowmeter

a. 12-inch Sensus Propeller meter location
b. 12-inch spacing between compression check valve and propeller flowmeter
c. Compression check valve

B. Flowmeter siting – KNOWLEDGE CHECK



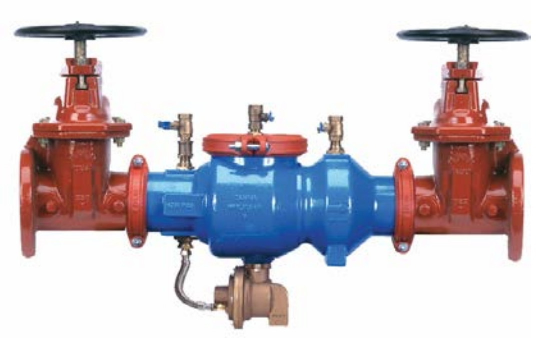
What feature shown in the photo might distort the velocity profile through the propeller flowmeter

a. Propeller meter location
b. Spacing between compression check valve and propeller flowmeter
c. Compression check valve

B. Flowmeter siting – **KNOWLEDGE CHECK**

Which of the below devices can straighten the flow in a pipeline?

a. Backflow preventer



c. Butterfly valve

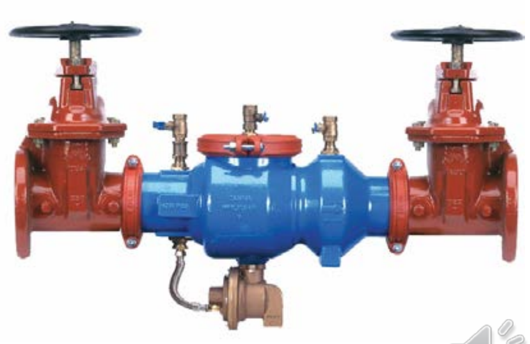
b. Check valve

d. Flow conditioners & strainers

B. Flowmeter siting – KNOWLEDGE CHECK

Which of the below devices can straighten the flow in a pipeline?

a. Backflow preventer



c. Butterfly valve

b. Check valve

d. Flow conditioners and strainers

A. Flowmeter Siting - Summary

Flowmeters: the *forgotten* asset

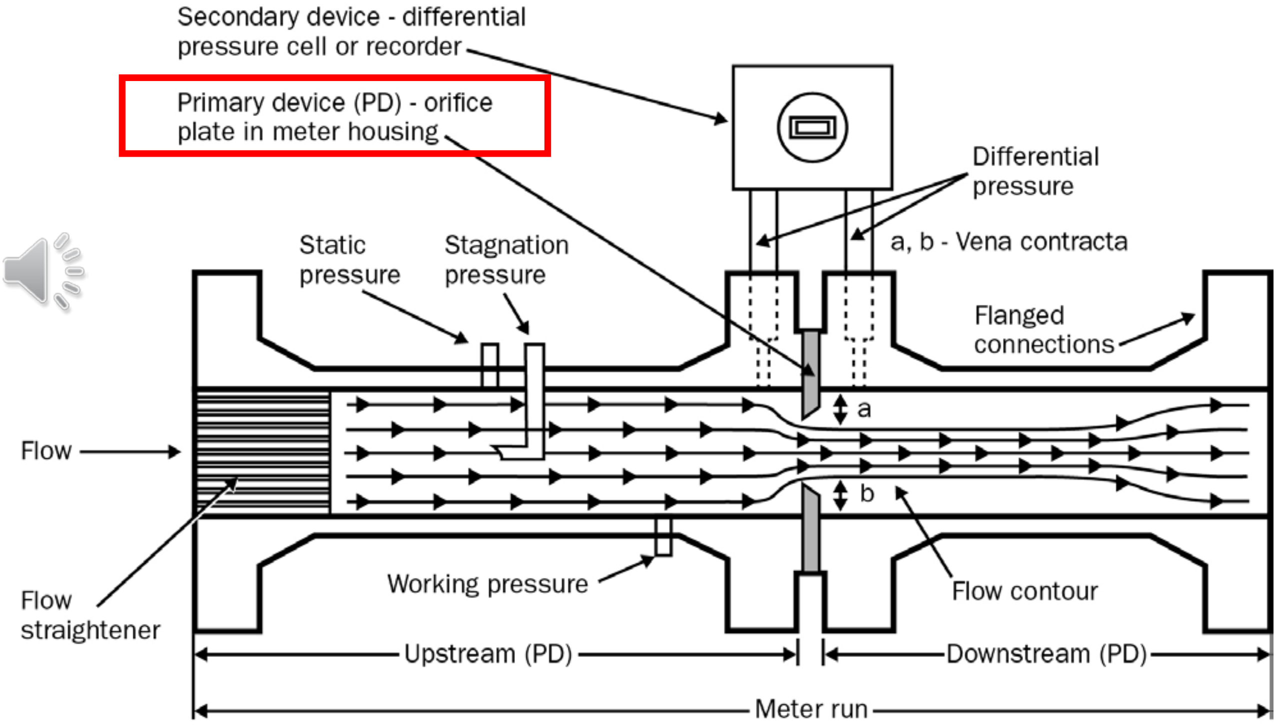
- Inspect your flowmeter installations if you don't have good data on them
- Make notes on any shortcomings that you observe in the siting or operation of the flowmeter
- Review purchase records or product specs if they exist
- Plan to correct any deficiencies that you find

B. Flowmeter Accuracy Testing

KEY TERM

- **<u>Verification</u>** confirms the accuracy of the primary device – the element that measures the flow of water; *this tests the performance of the flowmeter directly*
- Verification <u>is</u> flowmeter accuracy testing
- Flowmeter accuracy testing should be conducted regularly; at least once per year

Primary device and secondary device = Flowmeter Installation

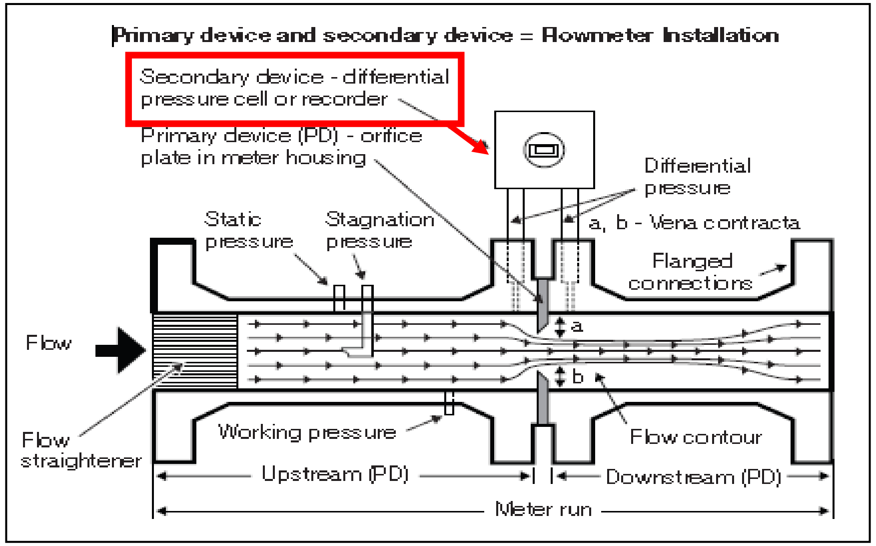


Orifice Plate Flowmeter components

B. Flowmeter Accuracy Testing

KEY TERM

- **<u>Calibration</u>** confirms the function of the secondary device; a data transfer device like a differential pressure cell, chart recorder, or similar device
- *Many water utilities regularly calibrate their secondary devices, without verifying/testing the primary device.*
- **CALIBRATION IS GOOD – BUT DOES <u>NOT</u> TEST FLOWMETER ACCURACY!**



Orifice Plate Flowmeter components

Bank of Differential Pressure Cells connected to flowmeters
(Courtesy of Louisville Water Company)

B. Flowmeter Accuracy Testing

Flowmeter Accuracy Testing Methods

- **Small flowmeters** (3-inch and smaller) – can remove and test on a test bench as is done with customer meters
- **Medium Sized flowmeters** (3-inch to 6-inch) – can test with truck mounted meter testing apparatus (same as testing large customer meters)
- **Large flowmeters** (larger than 6-inch) – test onsite using insertion or strap-on portable meters in series with the host meter, and compare measurements of both

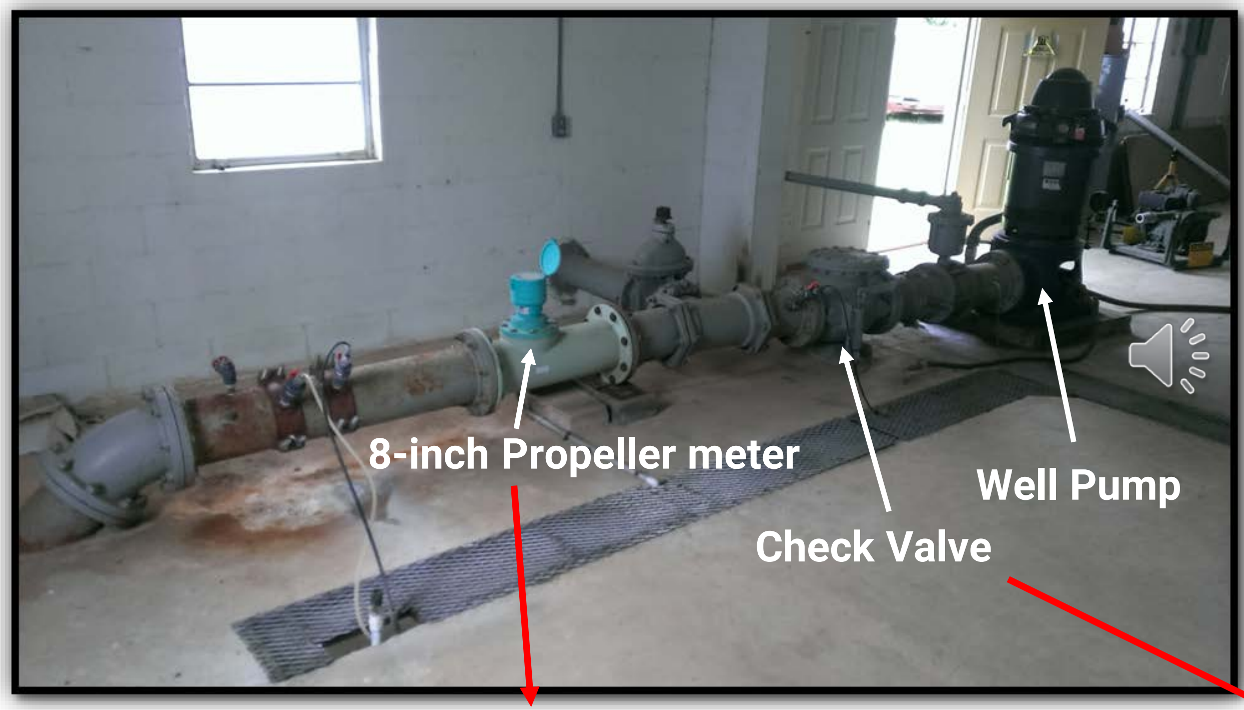
Calibrated test meter inside truck

Meter testing via truck mounted apparatus
(Courtesy of Louisville Water Company)

Pitot rod inserted in a large pipeline

B. Flowmeter Accuracy Testing

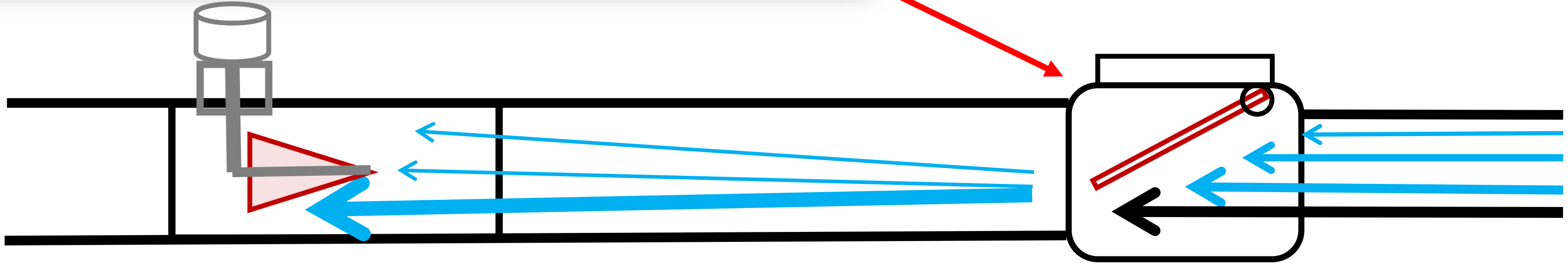
Caution: Offsite testing may not represent the meter as sited



Accuracy results from the manufacturer test bench reported as a strong **99.5% of flow**

Accuracy results from testing meter on site, or "in-situ", registered **142.2% or 42.2% over-registration!**

Check valve skews velocity and causes over-registration – this is not observed when the meter is tested on a test bench



B. Flowmeter Accuracy Testing

Small Meter Accuracy Testing

- Meter accuracy test apparatus (Meter Test Benches)
- Large capacity: large capacity test benches that test several dozen meters at one time
  - Good for larger utilities and professional testing services that test thousands of meters each year
- Small capacity: small test benches that test several meters at one time
  - Good for utilities that conduct their own testing on several dozen to several hundred meters each year

Large test benches that can test many meters at one time

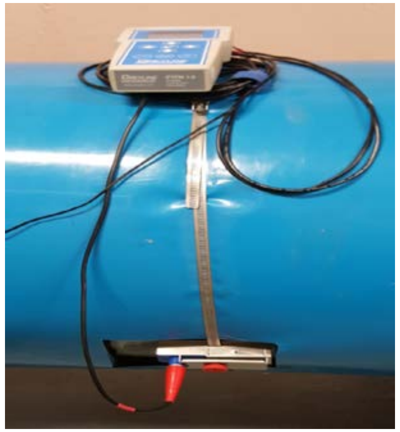
Small capacity meter test bench

B. Flowmeter Accuracy Testing

Large Meter Testing Methods

- Compare flowmeter readings with an inline insertion or strap-on meter measuring flow up- or down-stream of the primary meter
  i. Make certain that the temporary metering location has a good velocity profile
  ii. Strive for minimum 24-hr period of flow comparisons
- Document/store the inaccuracy values to serve as a basis for data adjustments included in the water audit

Pitot rod inserted in a 12-inch pipeline



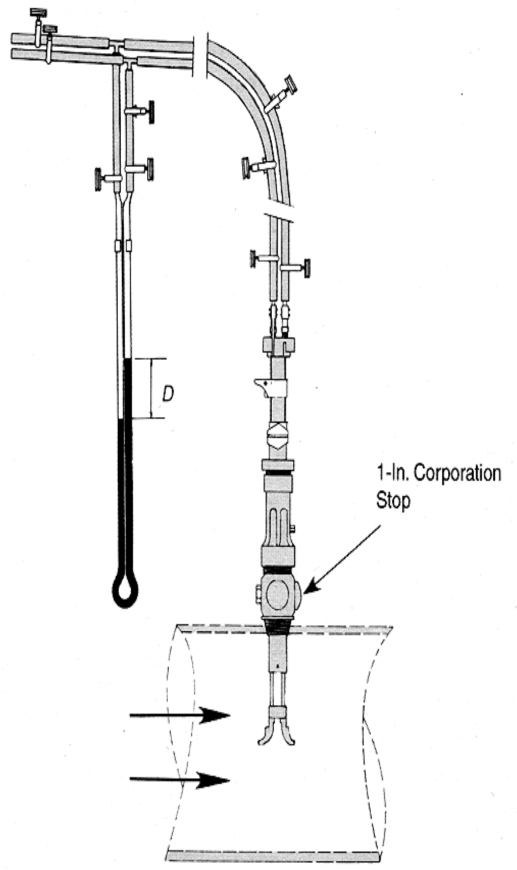
Strap-on ultrasonic meter to compare with flow registered by host flowmeter

B. Flowmeter Accuracy Testing

The Pitot Tube

Henri Pitot

Pipe caliper in 1-inch corporation stop



This form of Pitot tube, designed by Edward S. Cole in 1896, is used in leak surveys and for measuring flow and pipeline capacity.

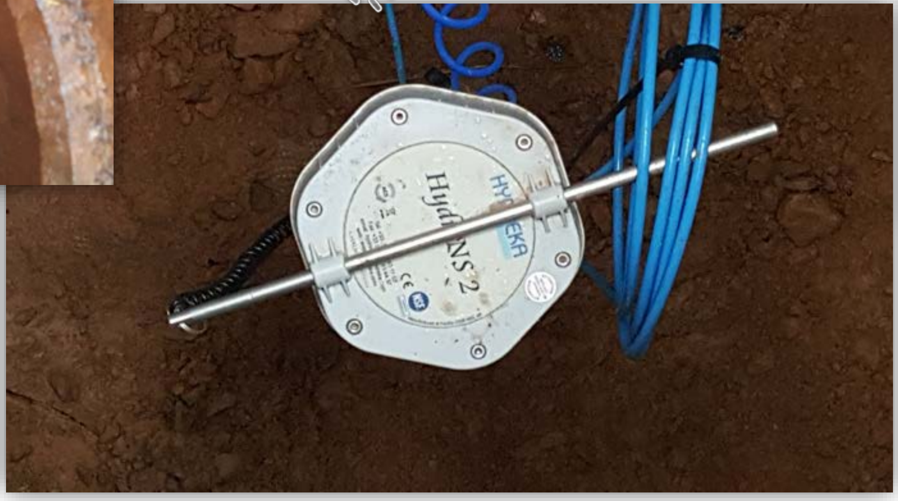
Figure 1-3 Modified Pitot tube

In a pitot tube, the height of the fluid column is proportional to the square of the velocity of the fluid at the depth of the inlet to the pitot tube. This relationship was discovered by Frenchman Henri Pitot in 1732, when he was assigned to measure flow in the River Seine.

The Pitot tube was designed by Edward S. Cole in 1896 and is used commonly to measure flow in pipelines

B. Flowmeter Accuracy Testing

Another Insertion Flowmeter



Hydreka electromagnetic insertion flowmeter

Primayer Xilog data logger records data on site

B. Flowmeter Accuracy Testing

Storage Tank or Clearwell Drop Test

- Feasible if a tank or clearwell is upstream of the flowmeter
- Stop water treatment for a few hours (this occurs in many small systems every day)
- During the test, water comes only from the tank or clearwell
- Divide tank volume by tank height to give the "volume per foot" of water stored.
- Chart the drop during the test, multiply this by "volume per foot" of water stored to get the volume "dropped"
- Divide this volume by the test duration to give the flowrate
- Compare the Drop Test rate to the flowmeter rate

Storage tank downstream of a water treatment facility allows a "drop test" to be conducted

B. Flowmeter Accuracy Testing: KNOWLEDGE CHECK

Which of the below activities is not a way to test a flowmeter for accuracy

a. Compare flowmeter volumes with the volumes measured by a downstream insertion flowmeter
b. Calibrate the differential pressure cells connected to a venturi flowmeter
c. Storage tank/clearwell drop test
d. Remove the flowmeter from service and test it on a calibrated meter accuracy test bench

B. Flowmeter Accuracy Testing: KNOWLEDGE CHECK

Which of the below activities is not a way to test a flowmeter for accuracy

a. Compare flowmeter volumes with the volumes measured by a downstream insertion flowmeter

b. Calibrate the differential pressure cells connected to a venturi flowmeter

c. Storage tank/clearwell drop test

d. Remove the flowmeter from service and test it on a calibrated meter accuracy test bench

B. Flowmeter Accuracy Testing: KNOWLEDGE CHECK

Which of the below are necessary to conduct a Drop Test to test a flowmeter for accuracy?

a. Have a configuration of ***treatment works – storage tank or clearwell – flowmeter*** in series

b. Know the geometry of the storage tank or clearwell

c. Confirmation that there is no leakage from the storage tank or clearwell

d. All of the above

B. Flowmeter Accuracy Testing: KNOWLEDGE CHECK

Which of the below are necessary to conduct a Drop Test to test a flowmeter for accuracy?

a. Have a configuration of ***treatment works – storage tank or clearwell – flowmeter*** in series

b. Know the geometry of the storage tank or clearwell

c. Confirmation that there is no leakage from the storage tank or clearwell

d. All of the above

B. Flowmeter Accuracy Testing: KNOWLEDGE CHECK – Question 1

The operator of the Anytown Water Utility conducted a Drop Test to test the accuracy of its production flowmeter and needed to execute the below calculations:

1. Anytown's circular storage tank is located between its treatment facility and its production flowmeter.

The storage tank holds 35,000 gallons and is 15 feet tall.

How many gallons are in each foot of stored water?

a. **2,333.3 gallons per foot**
b. **3,523.2 gallons per foot**
c. **1,500.0 gallons per foot**
d. **528,465 gallons per foot**

B. Flowmeter Accuracy Testing: KNOWLEDGE CHECK – Question 1

The operator of the Anytown Water Utility conducted a Drop Test to test the accuracy of its production flowmeter and needed to execute the below calculations:

1. Anytown's circular storage tank located between its treatment facility and its production flowmeter.

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b. **3,523.2 gallons per foot**
c. **1,500.0 gallons per foot**
d. **528,465 gallons per foot**

B. Flowmeter Accuracy Testing: KNOWLEDGE CHECK – Question 2

The operator of the Anytown Water Utility conducted a Drop Test to test the accuracy of its production flowmeter and needed to execute the below calculations:

2. The Drop Test was conducted for 3 hours (180 minutes) during which the storage tank dropped 3.85 feet.

Calculate the average flowrate of water passing through the production flowmeter based upon the drop in water level in the storage tank and select from the below.

a. **35.6 gallons per minute**
b. **12.8 gallons per minute**
c. **73.6 gallons per minute**
d. **49.9 gallons per minute**

B. Flowmeter Accuracy Testing: KNOWLEDGE CHECK – Question 2

The operator of the Anytown Water Utility conducted a Drop Test to test the accuracy of its production flowmeter and needed to execute the below calculations:

2. The Drop Test was conducted for 3 hours (180 minutes) during which the storage tank dropped 3.85 feet.

Calculate the average flowrate of water passing through the production flowmeter based upon the drop in water level in the storage tank and select from the below.

a. **35.6 gallons per minute**
b. **12.8 gallons per minute**
c. **73.6 gallons per minute**
d. 49.9 gallons per minute

B. Flowmeter Accuracy Testing: KNOWLEDGE CHECK

The final calculation of the Drop Test is to compare the average flowrate calculated from the drop in water (49.9 gal/min) with the rate measured by the flowmeter which was read and found to be 46.4 gal/min.

1. Knowing this, calculate the percent inaccuracy and select from the below choices.

2. Is this an over-registration or under-registration problem with the existing production flowmeter?

a. **10.62 %**
b. **7.01 %**
c. **1.36 %**
d. **5.14 %**

a. over-registration
b. under-registration

B. Flowmeter Accuracy Testing: KNOWLEDGE CHECK

The final calculation of the Drop Test is to compare the average flowrate calculated from the Drop in water (49.9 gal/min) with the rate measured by the flowmeter which was read and found to be 46.4 gal/min.

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a. **10.62 %**
b. **7.01 %**
c. **1.36 %**
d. **5.14 %**

a. over-registration

b. under-registration

C. Flowmeter Replacement

Reasons for Flowmeter Failure	Consequences of Flowmeter Failure
• Mechanical wear and tear • Corrosion • Mineral buildup • Age • Fouling (due to debris) • Mis-use • Poor piping configuration • Wrong calibration	• Inaccurate billing (export sales) • Lost revenue • Over- and under-feeding of treatment chemicals (raw water flowmeters) • Inaccurate annual reports and usage estimates • Errors in the data of the annual water audit • Errors in reports sent to regulatory agencies • An overall loss of control

C. Flowmeter Replacement

Good Practices for Flowmeter Upkeep

- Regular inspection
- Regular accuracy testing
- Regular calibration of secondary devices
- Repair of larger mechanical meters (turbine, propeller) where feasible and cost-effective
- Rotation of meters or primary elements of turbine meters
- Flowmeter replacement

C. Flowmeter Replacement

Flowmeter Repair

- May be feasible/economic for mechanical meters such as turbine and propeller meters, 3-inch and larger
- Generally, not cost-effective for smaller meters which are less expensive and more expedient to replace
- Repair is not feasible for static meters (magmeters, ultrasonic)

Flowmeter Rotation

- For meters 2-inch and smaller, consider having two of the same meter, with one rotated out-of-service every one-three years, then conducting testing and repair (if feasible)
- Certain turbine meters have a removable Unitized Measuring Element (UME), the primary flow measurement component, that can be easily removed and rotated

Unitized Measuring Element (UME) available for certain meters

Typical turbine meter

C. Flowmeter Replacement: KNOWLEDGE CHECK

Which of the below is not a consequence of inaccurate or failing flowmeters?

a. Errors in the annual water audit
b. Inaccurate billing and lost revenue for exported water
c. Reliable, accurate production flow data
d. Errors in reports sent to regulatory agencies

C. Flowmeter Replacement: KNOWLEDGE CHECK

Which of the below is not a consequence of inaccurate or failing flowmeters?

a. Errors in the annual water audit
b. Inaccurate billing and lost revenue for exported water
c. Reliable, accurate production flow data
d. Errors in reports sent to regulatory agencies

C. Flowmeter Replacement

Does your water utility have a plan for the replacement of your production flowmeter(s); including the target year for the replacement and estimated funding needed?

YES

NO

C. Flowmeter Replacement

1. *How many flowmeter do you have in your system?*
2. *List the number of meters in the matrix to the right*
3. *Also, list how many of these are over 20 years old*

Meter Type	Number in use	Number > 20 years old
Turbine		
Propeller		
Venturi		
Orifice Plate		
Magmeter		
Ultrasonic		
Single-Jet		
Multi-Jet		
Nutating Disc		
Other		
Totals		

If you don't have these numbers for the flowmeters of your system, you can consider filling out a matrix like this one to inventory your flowmeters

Module 2 Summary

Good flowmeter management includes proper selection, siting, and installation, which are critical steps to ensure accurate performance of the flowmeter

Regular accuracy testing of flowmeters is the best way to stay on top of the performance of your flowmeters

Flowmeter upkeep includes repair (where feasible), meter rotation, and – most importantly – replacement of flowmeters when they reach the end of their service life

MODULE 3

Tracking Production Flowmeter Data Accurately

Module 3 Agenda

A. Flowmeter Data Transfer Methods

B. Reviewing the Data Trail

C. Effective Data Management

Learning Objectives

As a result of this module participants should be able to:

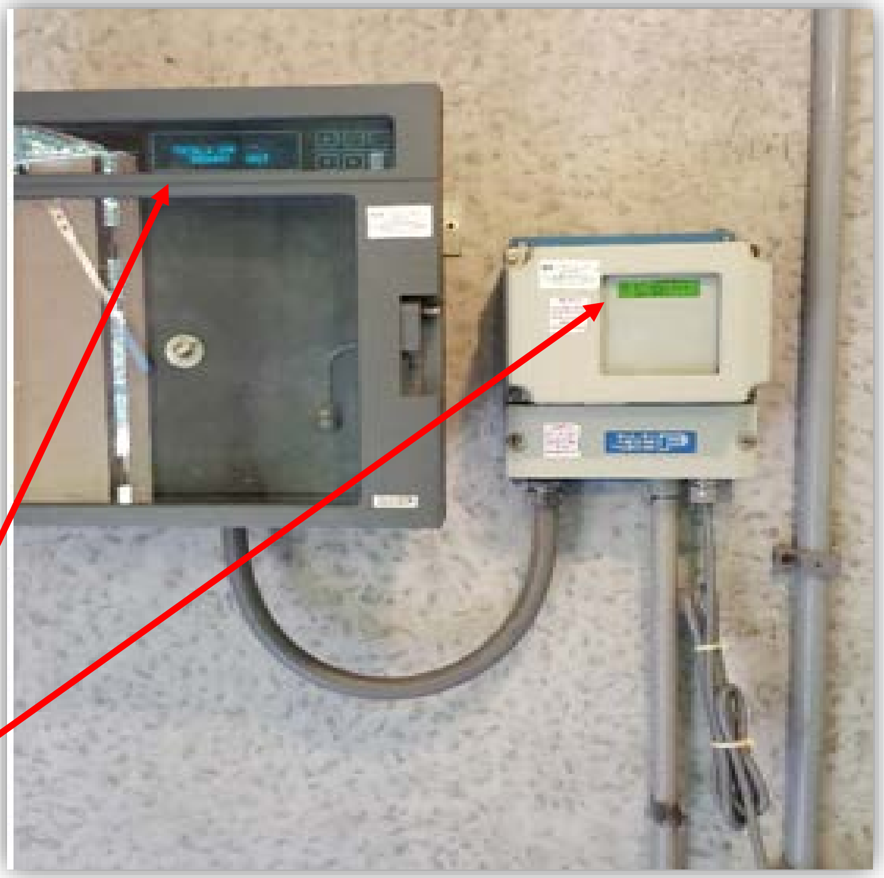
1. Identify the ways flowmeter data are transferred to central systems and reported
2. Scan data for possible errors
3. Manage the data trail produced by flowmeter readings

A. Flowmeter Data Transfer Methods

Manually Gathered Data

Some utilities visit flowmeter sites periodically and visually read data

- Typically collected daily
- Subject to reading errors



One utility was double-counting production water volumes – adding readings from two output devices from the same meter

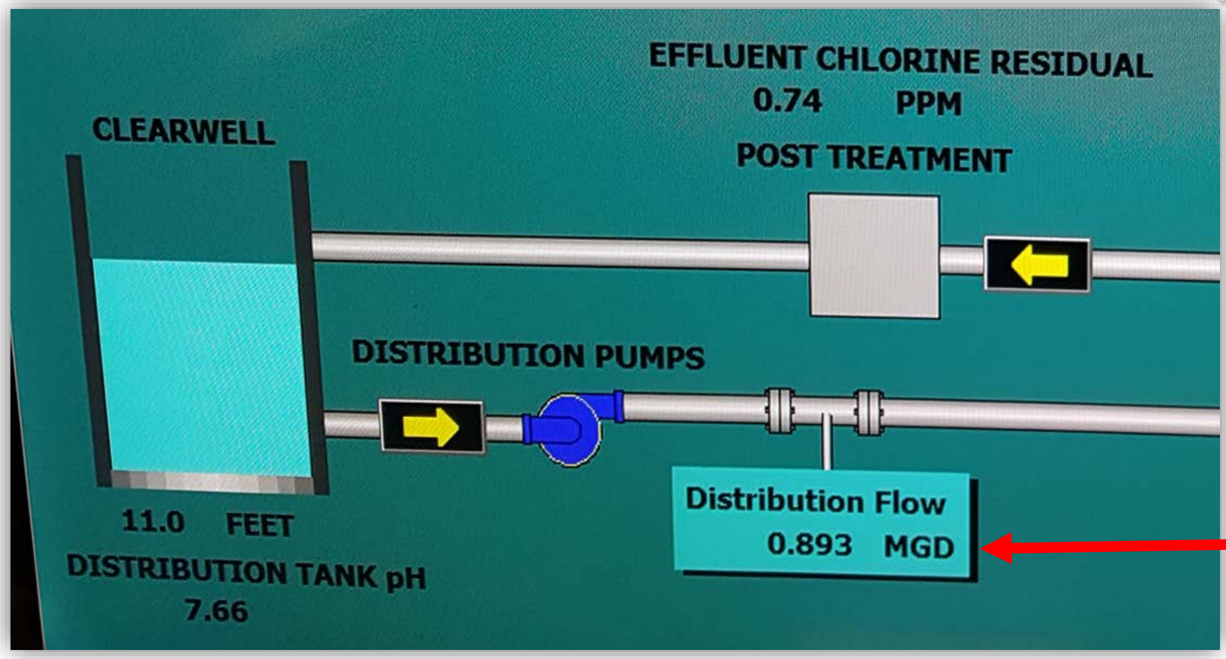
This inflated the Water from Own Sources volume and created a large volume of "ghost" Non-revenue Water

A. Flowmeter Data Transfer Methods

Continuously Collected Data

Usually collected via a Supervisory Control and Data Acquisition (SCADA) System

- Real-time data; hourly variation shown
- Data collected automatically
- Data record stored in history



SCADA System reports can be run automatically or on demand to assist operations or for regulatory reports

Production flowrate displayed on SCADA screen

B. Reviewing the Data Trail

Example of Water Pumping Data Gaps and Adjustments			
8/15/2012, hrs	High Service Pumping Rate, mgd actual flow	High Service Pumping Rate, mgd raw recorded data	High Service Pumping Rate, mgd adjusted data
0:00	8.69	8.69	8.69
1:00	8.65	8.65	8.65
2:00	8.32	8.32	8.32
3:00	8.11	8.11	8.11
4:00	7.94	0	8
5:00	8.02	0	8
6:00	8.44	0	8
7:00	8.98	0	9
8:00	9.34	0	9.3
9:00	9.25	0	9.3
10:00	9.17	0	9.3
11:00	9.12	9.12	9.12
12:00	9.27	9.27	9.27
13:00	9.22	9.22	9.22
14:00	9.08	9.08	9.08
15:00	8.99	8.99	8.99
16:00	9.14	9.14	9.14
17:00	9.18	9.18	9.18
18:00	9.25	9.25	9.25
19:00	9.22	9.22	9.22
20:00	8.82	8.82	8.82
21:00	8.78	8.78	8.78
22:00	8.75	8.75	8.75
23:00	8.71	8.71	8.71
0:00	8.68	8.68	8.68
Total	**212.43**	**151.29**	**212.19**
Average	**8.85**	**6.30**	**8.84**
Difference		**2.55**	**0.01**

Hourly flows from SCADA system for a utility showing data gap from 4:00 – 10:00 AM and data adjustment with estimated flows

The Data Trail: how data gets to final reports

- Manual collection: not granular
- SCADA data: granular data, best to review each business day for data gaps and data errors
- Data gaps can occur due to:
  - Unplanned interruption: lightning strike, power failure
  - Planned interruption: instrumentation calibration
- Data gap corrections can be restored to totals
  - The example shows an error of 2.55 mg causing under-statement if an adjustment is not made

B. Reviewing the Data Trail

Town Water Company (TWC) Annual Report of Monthly Water Production						
Month (2019)	Water from Own Sources Treatment Plant, gal	Water from Own Sources Well #1, gal	Water from Own Sources Well #2, gal	Water from Own Sources Total, gal	Water Imported (from XYZ Utility), gal	Water Supplied Volume, gal
January	62,915,423			62,915,423		62,915,423
February	62,678,257			62,678,257		62,678,257
March	63,374,921			63,374,921		63,374,921
April	63,518,299			63,518,299		63,518,299
May	66,940,949	22,853	15,421	66,979,223		66,979,223
June	67,833,324	37,423	16,875	67,887,622		67,887,622
July	69,164,957	41,768	17,189	69,223,914	9,878,267	79,102,181
August	69,920,897	43,221	17,005	69,981,123	12,097,944	82,079,067
September	67,868,777	28,231	11,421	67,908,429	11,023,789	78,932,218
October	64,923,227			64,923,227		64,923,227
November	64,282,150			64,282,150		64,282,150
December	63,827,412			63,827,412		63,827,412
Total	787,248,593	173,496	77,911	**787,500,000**	**33,000,000**	**820,500,000**
Ave, gal/day	2,156,845.4	475.3	213.3	2,157,534	90,410	2,247,945

The Data Trail: Final Summary Reports

- Recommend a monthly summary report
- Review and correct errors/data gaps
- Cumulative data adjustments can be part of the 'Water Supplied Error Adjustment' in the water audit
- Key water audit volumes are shown in bold in the table

C. Effective Data Management

The Mass Balance Method

County Water Authority
Mass Balance Report for 2019

Date	Raw Water Pumping Volume	Treated Water Effluent Volume	Difference Raw Water - Treated Water	Difference Percentage
7/1/2019	201,456	189,676	11,780	5.85%
7/2/2019	203,073	190,981	12,092	5.95%
7/3/2019	202,398	190,545	11,853	5.86%
7/4/2019	202,123	190,376	11,747	5.81%
7/5/2019	201,823	190,121	11,702	5.80%
7/6/2019	201,632	190,002	11,630	5.77%
7/7/2019	202,897	190,678	12,219	***6.02%***
7/8/2019	203,223	190,970	12,253	***6.03%***
7/9/2019	203,689	191,374	12,315	***6.05%***
7/10/2019	203,882	191,423	12,459	***6.11%***
7/11/2019	203,921	191,223	12,698	***6.23%***
7/12/2019	204,123	190,723	13,400	***6.56%***
7/13/2019	203,845	190,222	13,623	***6.68%***
7/14/2019	203,645	189,187	14,458	***7.10%***
7/15/2019	203,445	188,976	14,469	***7.11%***

- Use with two or more production flowmeters in series such as:
  - Flowmeter for raw water
  - Flowmeter for treated water effluent
- The method compares daily differences of these volumes
- Under normal conditions the percentage difference between the two should be similar
- Increased difference around July 7th suggests one of the meters, likely treated water, is under-registering

C. Effective Data Management - **KNOWLEDGE CHECK**

What problems can occur in production flowmeter data?

a. Double-counting production flows
b. Data errors
c. Data gaps
d. All of the above

Effective Data Management - **KNOWLEDGE CHECK**

What problems can occur in production flowmeter data?

a. Double-counting production flows
b. Data errors
c. Data gaps
d. All of the above

Effective Data Management - **KNOWLEDGE CHECK**

True or False: You can use the Mass Balance Method if you have only one production flowmeter?

True

False

Effective Data Management - **KNOWLEDGE CHECK**

True or False: You can use the Mass Balance Method if you have only one production flowmeter?

True

False

Module 3 Summary

Collecting flowmeter data reliably is critical to maintain an accurate record of water supply data

The data trail is the path your data takes from the flowmeter to final reports; it's important to know and understand this path

Routinely reviewing flowmeter data will help identify data gaps or data errors that can corrupt the accuracy of the data

The Mass Balance Method is a useful technique to watch for data issues, but it can only be used if you have two or more production flowmeters in series at one supply system

Course 2 Summary

Production flowmeters are critical assets and the data that they produce is essential to accurately quantify Non-revenue water

Water utilities can practice good production flowmeter management by knowing that:

- Many different types of meters exist; meter selection and siting is important
- Flowmeters should be regularly tested for accuracy to chart their performance
- Flowmeters should be repaired, rotated, or replaced at regular intervals to ensure good functionality

Production flowmeter data should be carefully monitored and managed to ensure good data integrity

Course 2

Final Assessment Questions

(see separate document)

ACCURATE METERING OF WATER PRODUCTION FLOWS – EL312

Disclaimer

If you find an error in this eLearning module, please email AWWA Education Services at educationservices@awwa.org

Course 3 Preview

Effective Leakage and Pressure Management to Contain System Leakage

This course will present best practices for leakage control by covering leak detection, pressure management and other methods, including:

- Ways to analyze leakage occurrences and loss rates
- Latest technologies for leak detection and leakage control
- The innovative techniques of pressure management

Thank you for completing Course 3

AWWA eLearning

Effective Leakage and Pressure Management to Contain System Leakage