Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

Asia–Pacific
Legal Metrology Forum

WATER METERS

Training Course on
Pattern Approval and Verification of Water Meters – OIML R49
15 – 18 October 2019 at NMIM, Sepang, Malaysia

'Instrument intended to measure continuously, memorize and display the volume of water passing through the measurement transducer at metering conditions' - OIML R 49-1: 2013

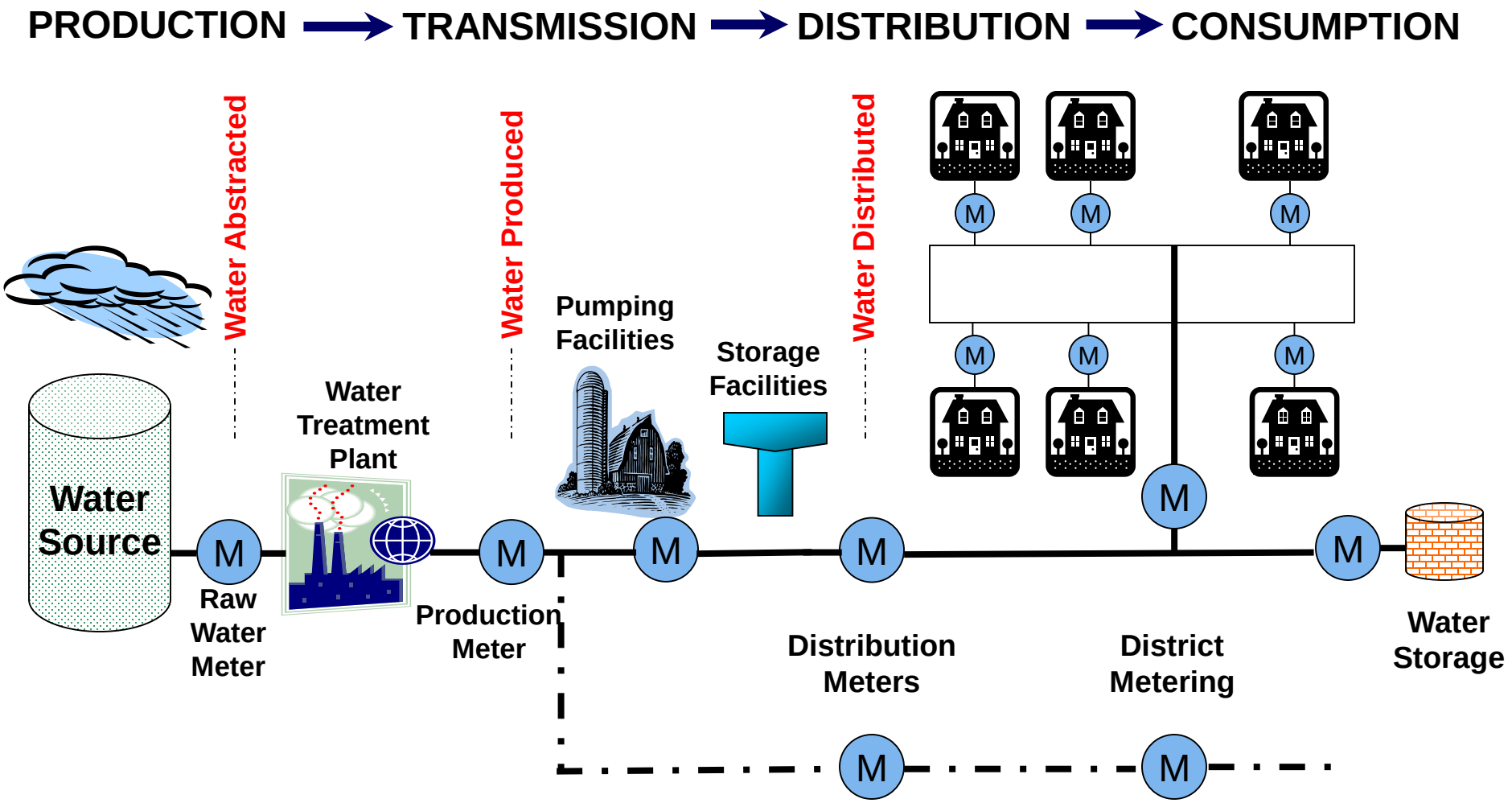









METERING IN A WATER DISTRIBUTION SYSTEM



Water Meters

Applications for Water Utilities:

Small size meters – residential/domestic

Intermediate size meters – small commercial

Large Meters

- **Industrial**
- **Commercial – large Institutional**

Customer Billing

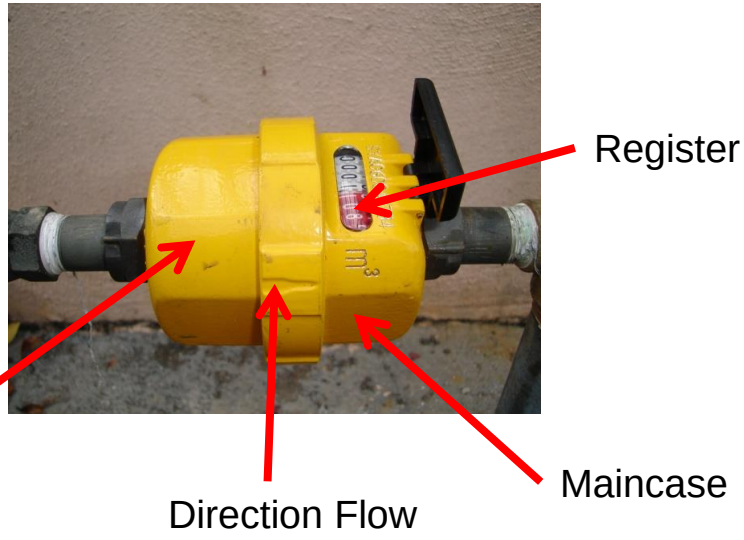
Water Utility Meters

- Positive Displacement
- Velocity
  - Multi-jet
  - Single-jet
  - Turbine
- Compound (Combination)
- Fire-service
- Fluidic Oscillator
- Electromagnetic
- Ultrasonic

Positive Displacement Meter

Operation:
When operated under positive pressure, water physically displaces the moving measuring element in direct relation to the amount of water that passes through the meter.

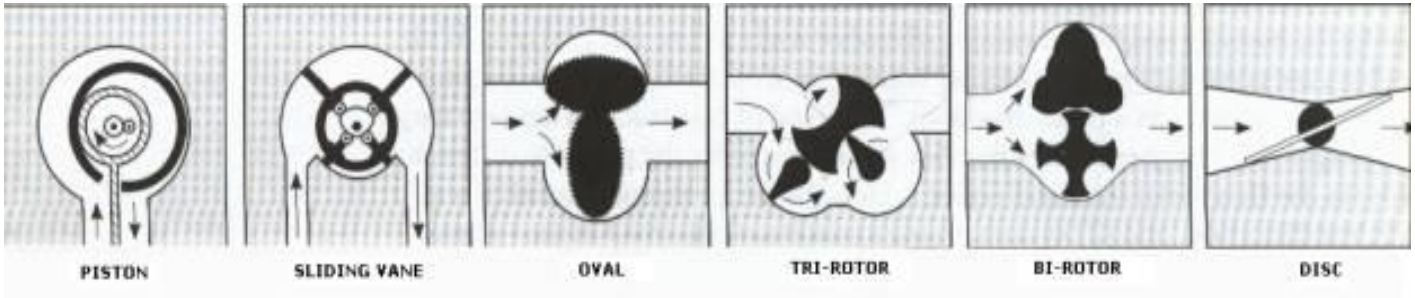
Applications:
•Residential
•Small commercial



Basic Meter Components

Positive Displacement Meter

- **Most Common:**
  - Oscillating Piston
  - Nutating Disc
- **Other Types:**
  - Sliding Vane
  - Oval Gear
  - Tri-rotor
  - Bi-rotor



Positive Displacement Meter

Meter Size (mm)	Minimum Flowrate M^3/h	Normal Flowrate M^3/h
13	0.06	0.2 – 3.4
15	0.06	0.2 – 4.5
20	0.11	0.5 – 6.8
25	0.17	0.7 – 11.4
40	0.34	1.1 – 22.7
50	0.45	1.8 – 36.3

Source: AWWA C 700

Ex: Australia 20 mm PD meter

Minimum flow rate: 0.02 m^3/h

Normal flow rate: 0.032 to 4.0 m^3/h

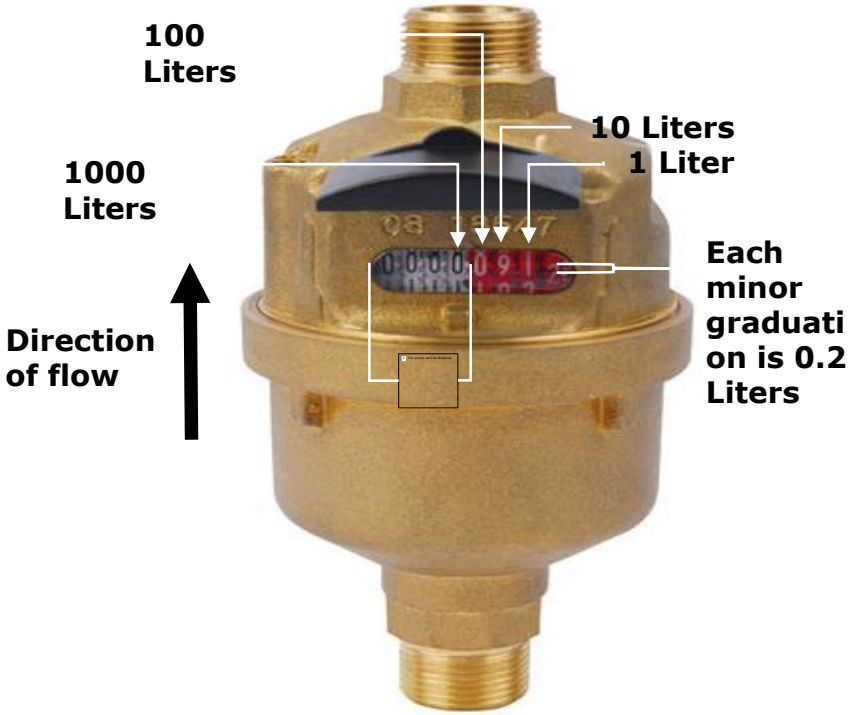
Maximum flow rate: 5.0 m^3/h

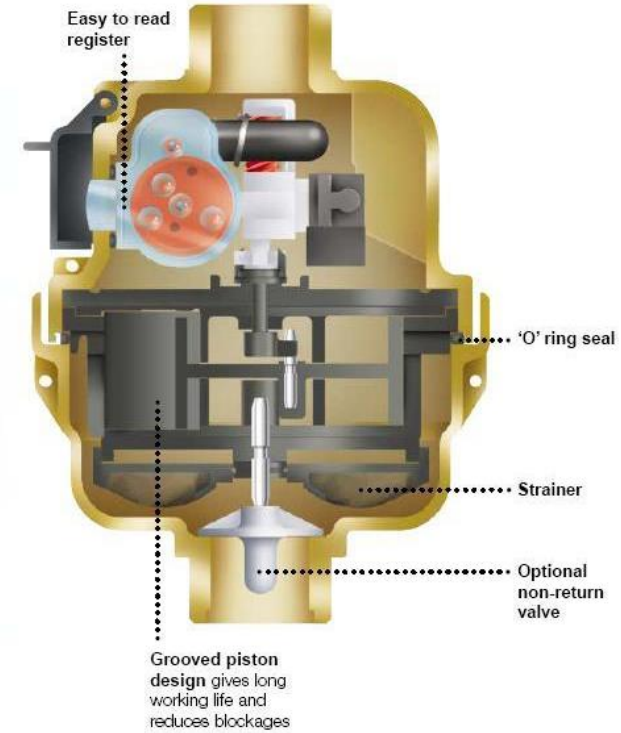
Oscillating Piston Meter

- Water flows into a measuring chamber where it operates a piston.
- The piston moves freely and oscillates around a central hub.
- The piston is guided by a rubber-coated division plate.
- A drive magnet, incorporated in the piston, rotates around the outside of a hermetically sealed register well and magnetically drives the “follower” magnet sealed within the well.
- The “follower” magnet drives a crank connected to the register gear train, which translate the number of piston oscillations into volume totalization.

Positive Displacement Meter

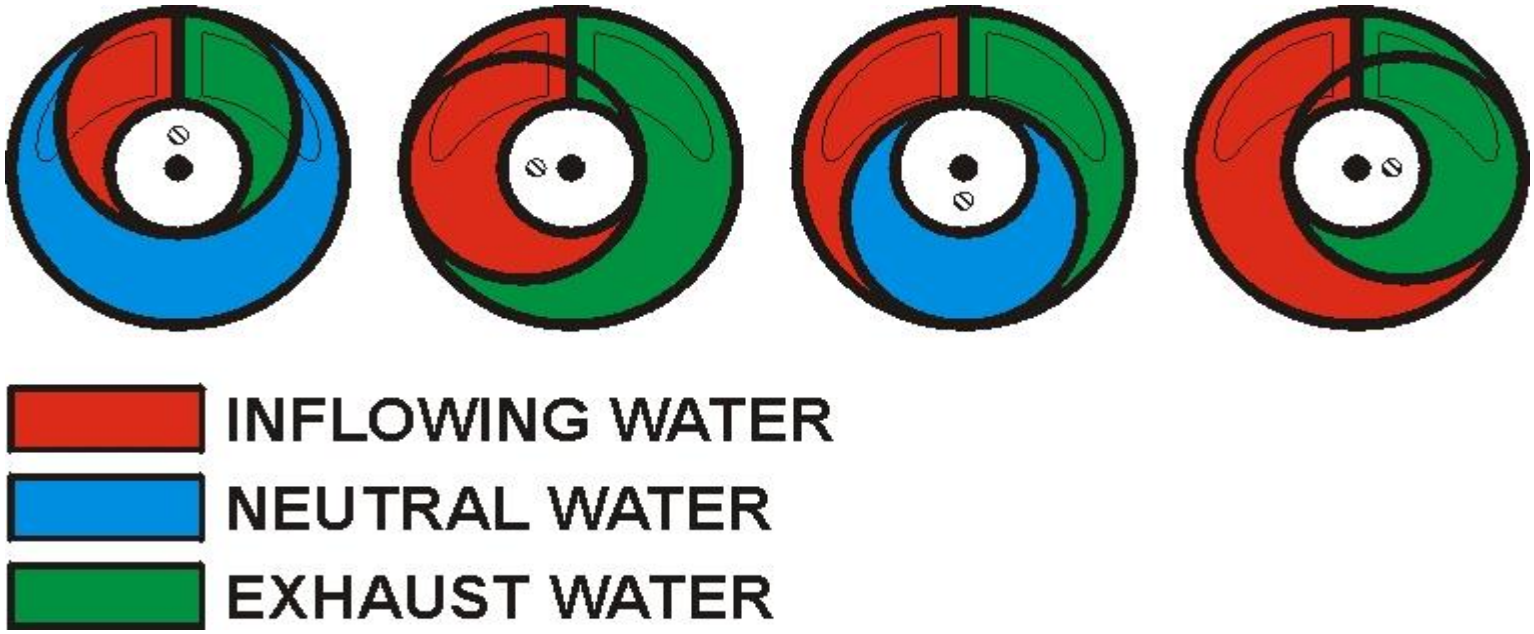
Basic Meter Components:



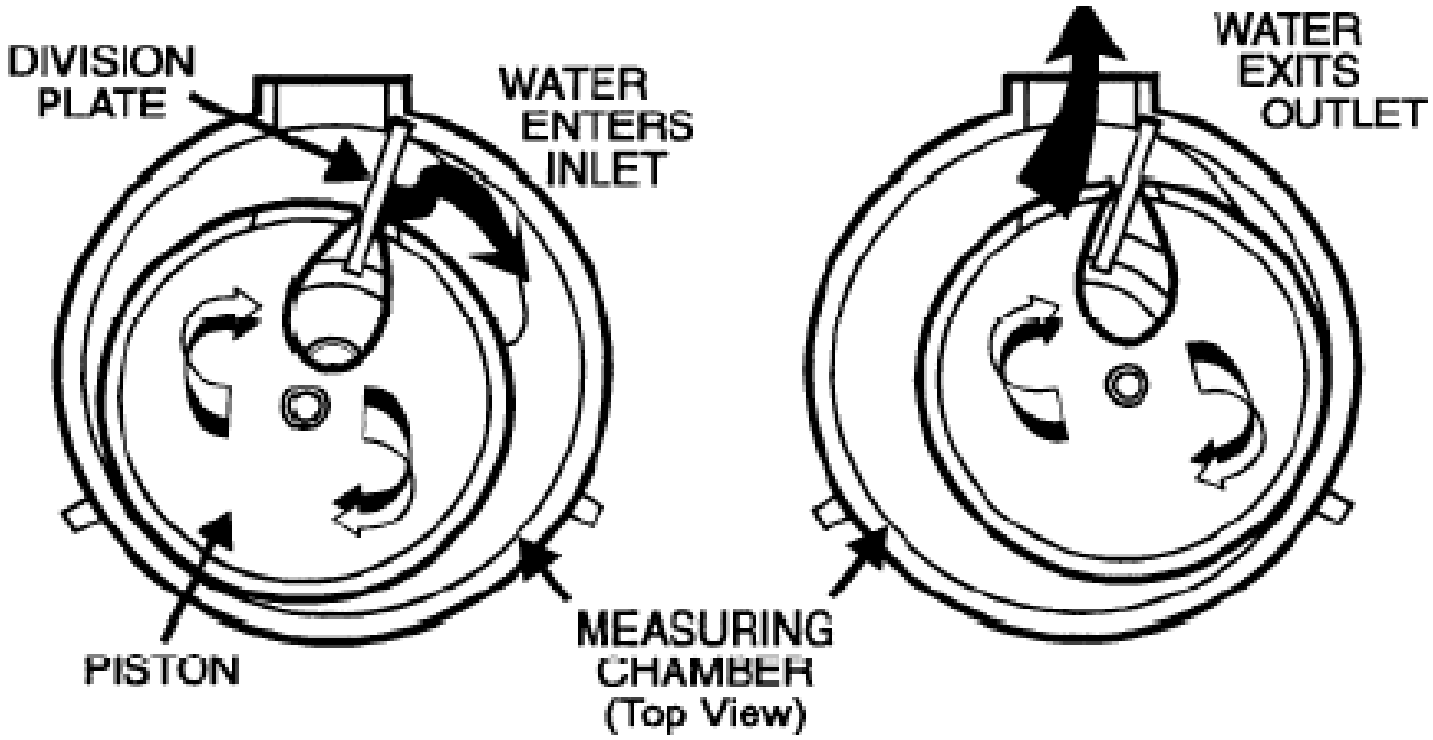


Oscillating Piston Meter

For each revolution of the piston a fixed volume of water is displaced

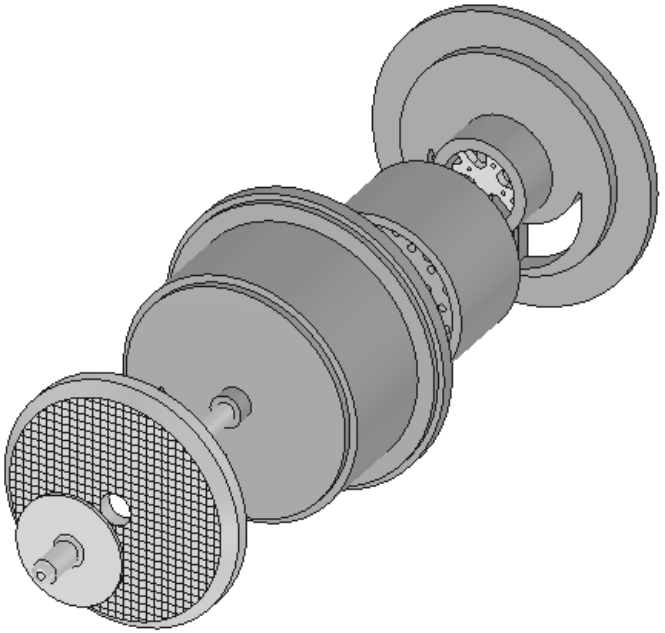


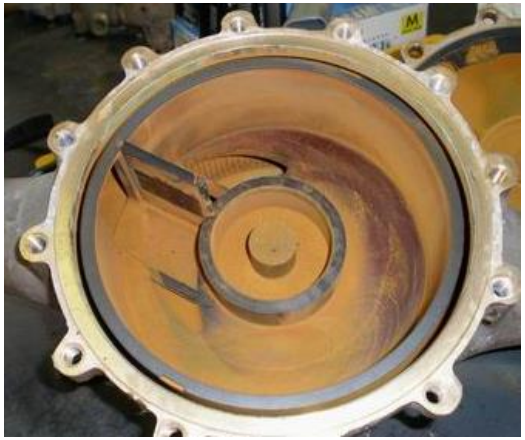
Oscillating Piston Meter



Oscillating Piston Meter

Item Description	Diagram
Counter Housing	
Counter Register	
Ramp	
Measuring Chamber	
O-Ring	
Restrainer	
Chamber Housing	





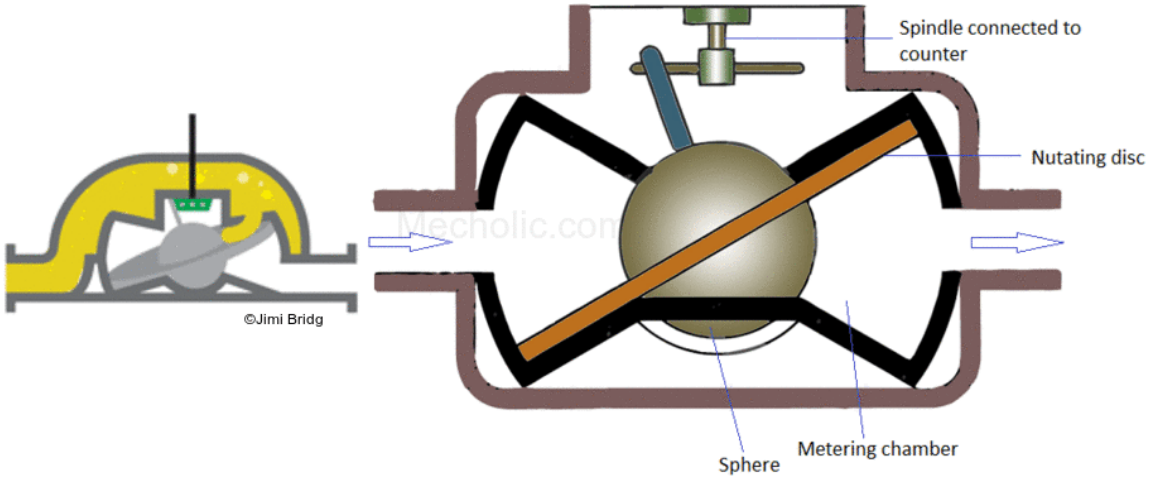
Measuring chamber – piston removed bottom view)

oscillating piston (bottom view)

Nutating Disc Meter

- Water flows into a measuring chamber where it causes a disc to nutate.
- The disc nutates freely on a ball.
- The disc is guides by a thrust roller.
- A drive magnet transmits the motion of the disc to a follower magnet located within the permanently sealed register.The follower magnet is connected to the register gear train.
- The gear train reduces the disc nutations into volume totalization units displayed on the register dial face.

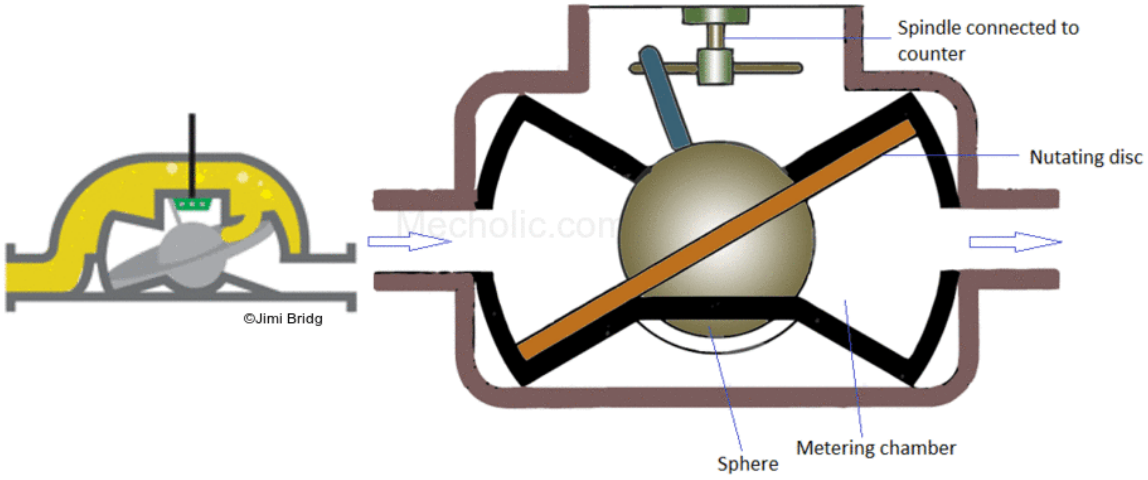
Nutating Disc Meter

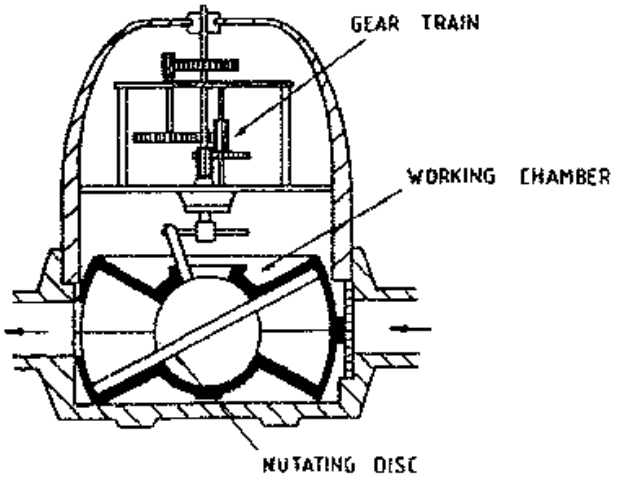


- The disc divides the chamber into two equal volume. In above figure, water enters at the left side of the eccentrically mounted disc. The liquid pressure sets the disc in motion, results in the quantity of liquid that enters left side of the chamber will be rolled out through the outlet. When the disc and ball wobble it generate a cone with the apex at geometric center, this motion is getting translated into a rotary motion of shaft by the pin fastened to the ball.

Nutating Disc Meter

- The movement of the disc is then transmitted by the cam and gear train to the totalizer or pulse transmitter. Each complete cycle of nutation of the disc will be counted by the counter mechanism which can be directly calibrated in terms of volume of liquid received or discharged. Each evolution of disc indicates the passage of fixed volume of fluid.





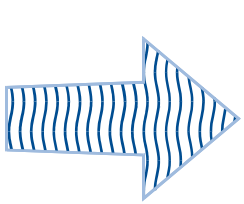
Velocity Meter

Operation:

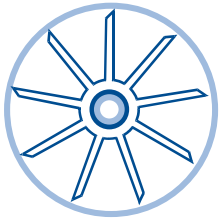
A velocity-type meter measures the velocity of flow though a meter of a known internal capacity. The speed of the flow can then be converted into volume of flow usage.

Applications	Meter Type
residential/domestic	multi-jet single-jet
small commercial	multi-jet single-jet turbine
large ICI	single-jet turbine

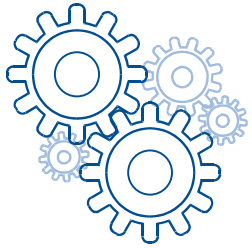
Velocity Meter



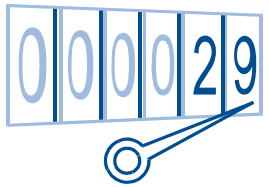
Water flow



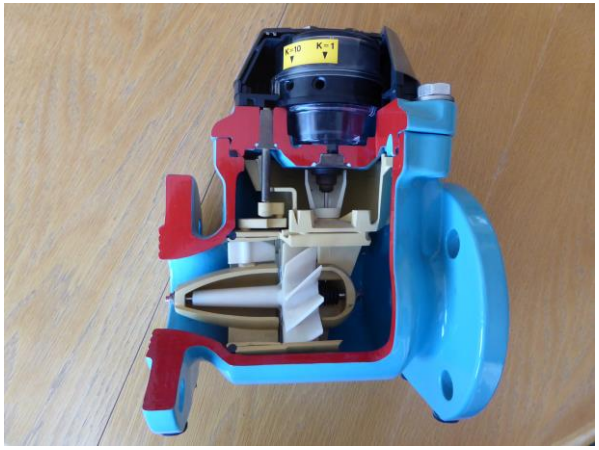
Impeller



Gears



Odometer -
volume registration



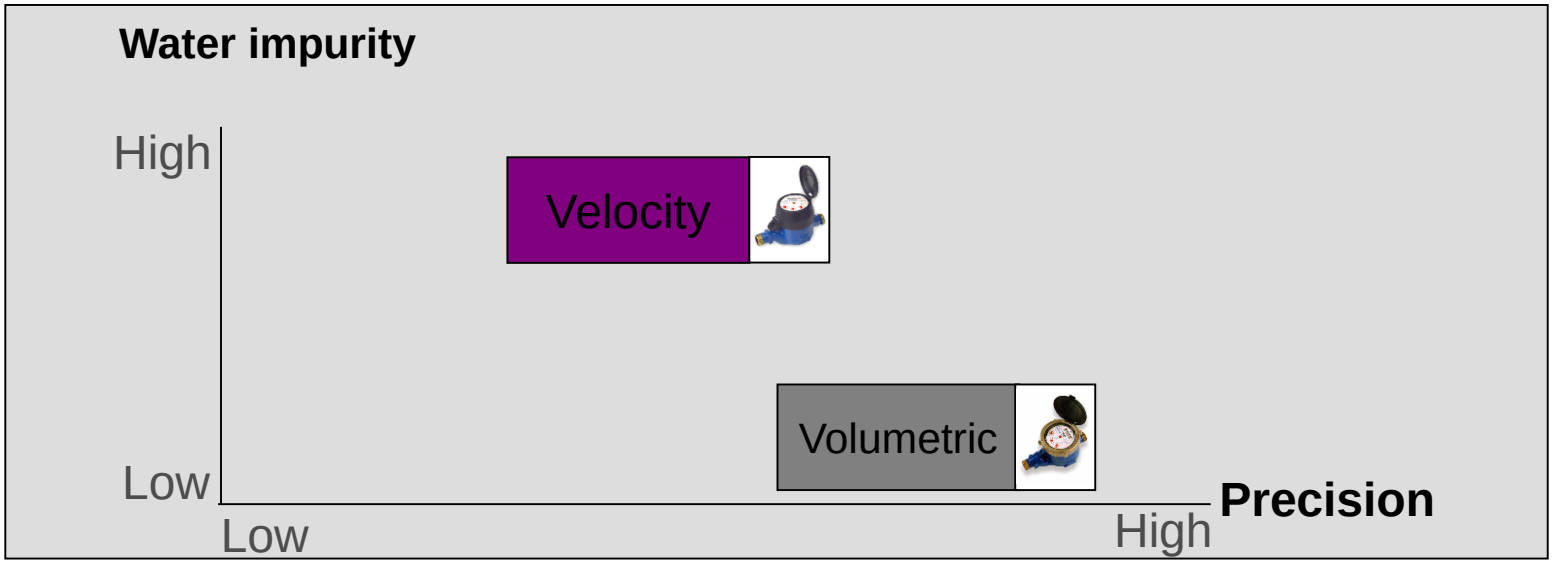
Velocity Meter vs. PD Meter

Velocity Meter

- Sensing velocity of water
- Better precision if equipped with calibration device
- Functions in water containing impurities

PD Meter

- Sensing volume of water
- High precision no calibration
- Sensitive to water impurity



Geographical Implementation

(Domestic Meters)

Velocity Meter

- Rest of Europe, Southern USA
- Latin America
- Japan and Far East

PD Meter

- USA and Canada
- UK, France, Portugal, Cyprus
- H.K. Australia, Singapore

Source; ARAD Meter

Multi-jet Meter

Operation:

•Multi-jet meters use multiple ports surrounding the internal measuring chamber, to create a jet of water against an impeller.

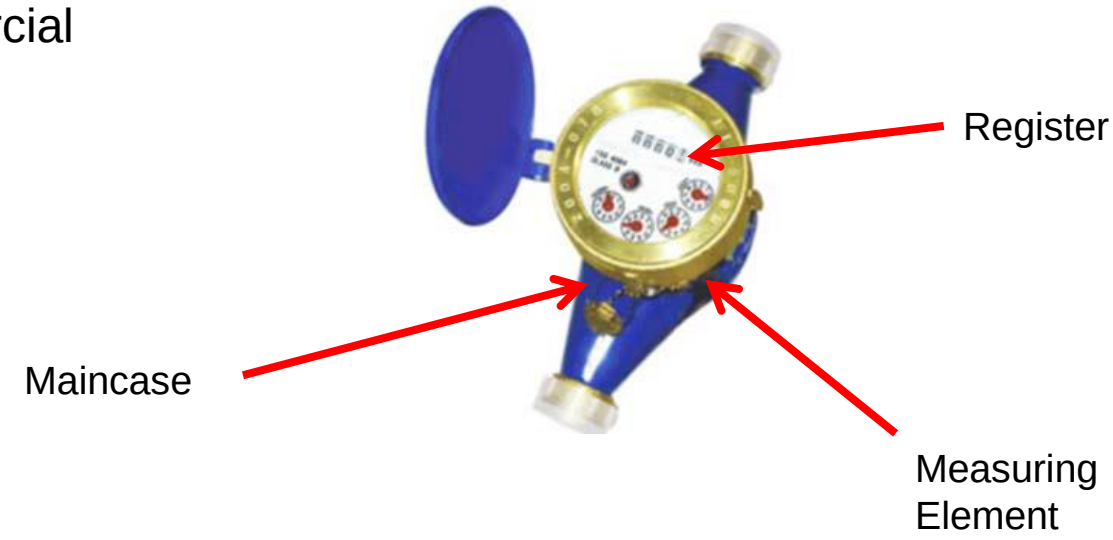
•The impeller rotation speed is in relation to the velocity of water flow.

•A magnet and gear train converts the number of rotations into a volume which is displayed on the indicating device (register dial face).

Applications:

•Residential

•Small commercial



Multi-jet Meter

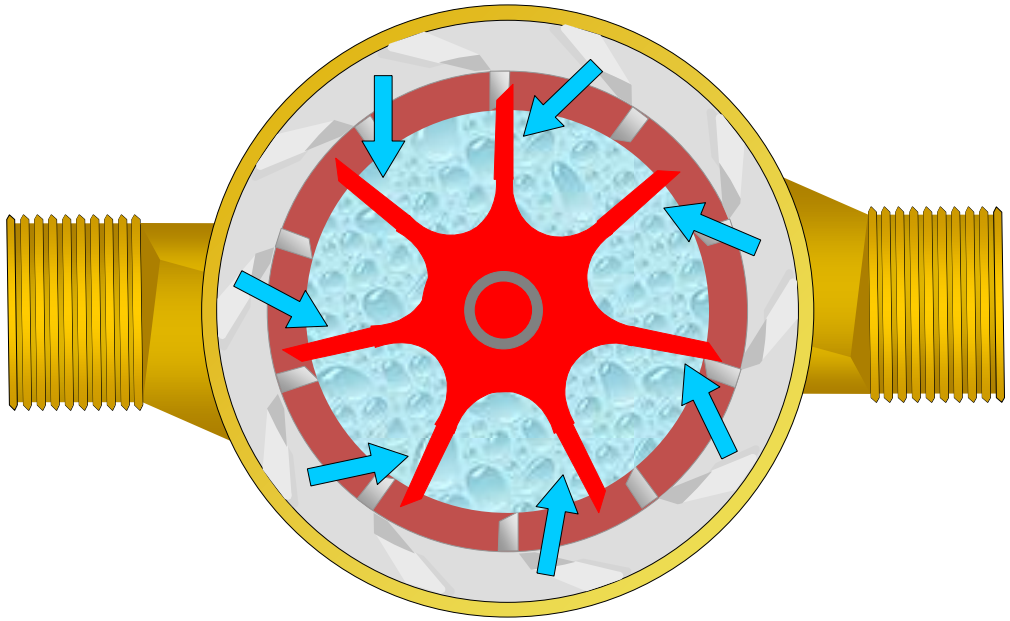
Size and Flow Rates:

Meter Size (mm)	Minimum Flowrate M^3/h	Normal Flowrate M^3/h
15	0.06	0.2 – 4.5
20	0.11	0.5 – 6.8
25	0.17	0.7 – 11.4
40	0.34	1.1 – 22.7
50	0.45	1.8 – 36.3

Source: AWWA C 708

Multi-jet Meter

- **Water flows via tangential entries and push the impeller.**
- **All impeller wings are in touch with water simultaneously while water flows.**
- **Some models equipped with an adjusting port to allow for recalibration, compensate for inaccuracy in older meters**



Multi-jet Meter

Dry transmission

Magnetic transmission between impeller and the register

Wet Transmission

Direct transmission between impeller and register

Multi-jet Meter

India

China

USA

Single-jet Meter

Operation:

- A tapered inlet creating a single jet of water that is projected into the measuring chamber where it strikes the blades of the impeller.
- The impeller rotation speed is in relation to the velocity of water flow.
- A magnet and gear train converts the number of rotations into a volume which is displayed on the indicating device (register dial face).

Single-jet Meter

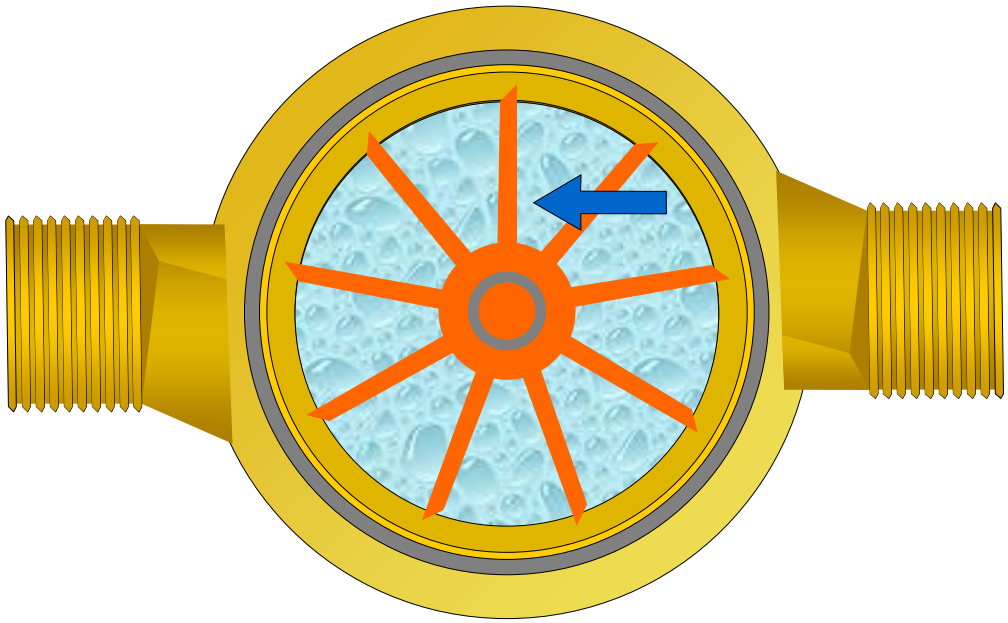
Sizes and Flowrates:

Meter Size (mm)	Minimum Flowrate M^3/h	Normal Flowrate M^3/h
13	0.007	0.03 – 3.4
15	0.015	0.06 – 4.5
20	0.029	0.12 – 6.8
25	0.057	0.17 – 11.4
40	0.11	0.34 - 23
50	0.11	0.45 – 36
75	0.11	0.57 - 73
100	0.17	0.68 – 110
150	0.34	0.91 – 220

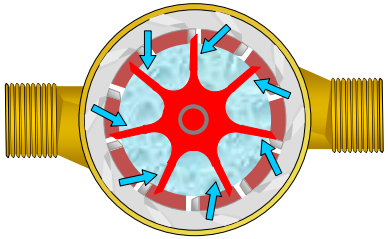
Source: AWWA 712 & Actaris

Single-jet Meter

- **Body has only single water entry and exit.**
- **While water flows only one wing of the impeller is being touched**

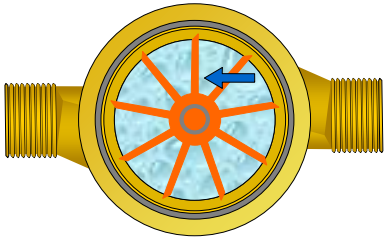


Multi-jet vs. Single-jet



Multi- jet

- **High resistance to flow**
- **Longer life expectancy**
- **Many parts**
- **More expensive**
- **Less sensitive to installation conditions**
- **Most utilized meter worldwide**



Single jet

- **Limited resistance to flow**
- **Shorter life expectancy**
- **Economic solution**
- **Sensitive to installation conditions**
- **Popular for sub-metering applications**

Turbine Meter

Operation:

- Water passes through the meter and drives a rotor or vane
- The number of rotations of the rotor or vane is in direct proportion to the quantity of water passing through the meter.
- Rotor revolutions are transferred to an indicating device by appropriate reduction gearing, magnetic drives or electronic sensors.
- Vertical or horizontal rotor design
- AKA: woltman meter, helical rotor meter

Turbine Meter

Operation:

•Water passes through the meter and drives a rotor or vane

•The number of rotations of the rotor or vane is in direct proportion to the quantity of water passing through the meter.

•Rotor revolutions are transferred to an indicating device by appropriate reduction gearing, magnetic drives or electronic sensors.

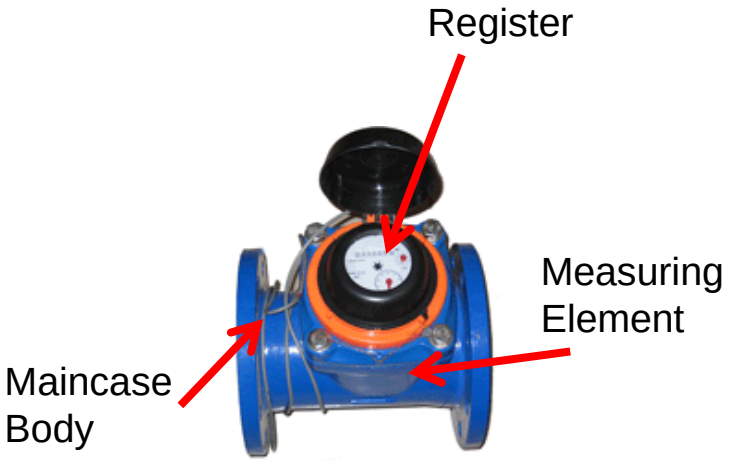
•Vertical or horizontal rotor design

•AKA: woltman meter, helical rotor meter

Applications:

•Small commercial

•Widely used for very high flow rate



Turbine Meter

Sizes and Flowrates:

Meter Size (mm)	Normal Flowrate M^3/h
40	0.9 – 27
50	0.9 – 436
75	1.8 – 99
100	3.4 – 170
150	6.8 – 360
200	11 – 640
250	17 – 950
300	27 – 1,200
400	45 – 1,770
500	68 – 2,730

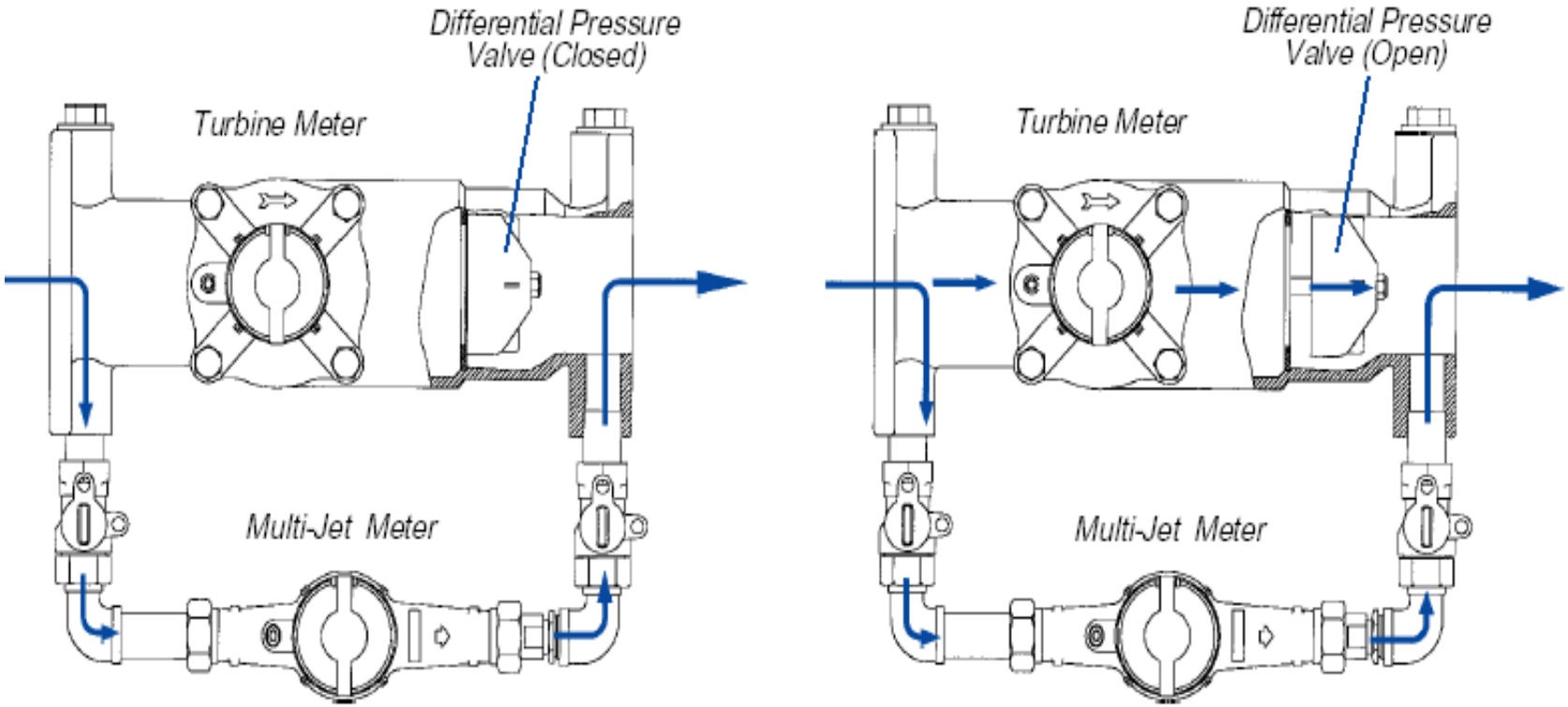
Source: AWWA 701

Compound (Combination) Meter

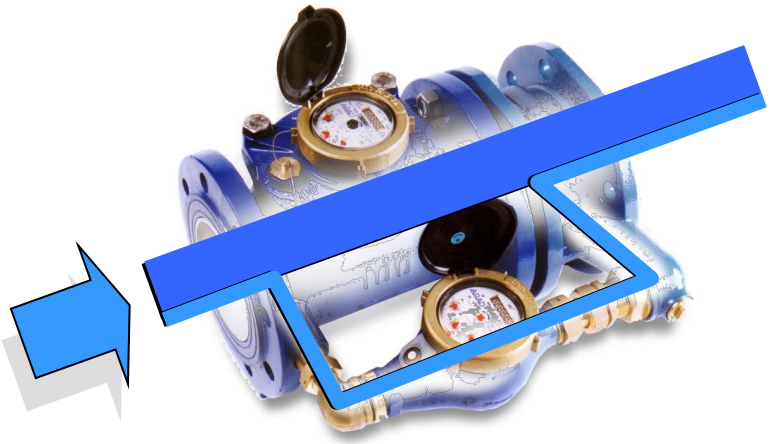
Operation:

- Compound meters have two measuring elements and a changeover device valve to regulate flow between them.
- At high flow rates, water is normally diverted primarily or completely to the turbine part of the meter.
- When flow rates drop to where the turbine meter cannot measure accurately, a changeover device valve closes to divert water to a smaller meter.
- The low flow meter is typically a multi-jet or PD meter.
- The volume of water is displayed on a single register or by adding the registration of the high and low meter registers.

Compound Meter

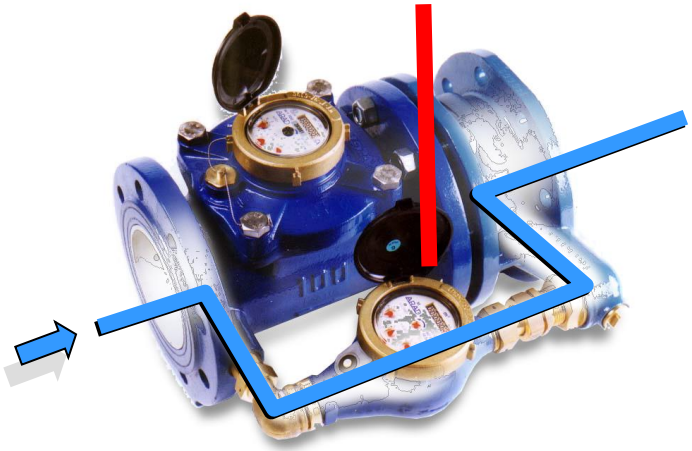


Compound Meter



High Pressure

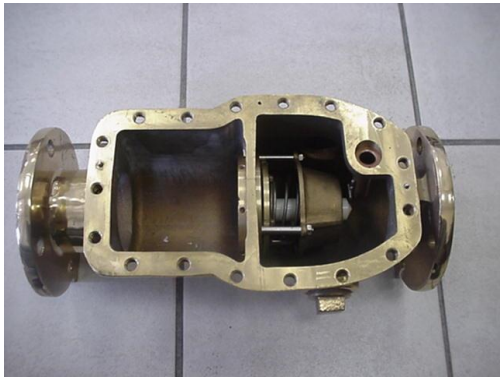
High Flow

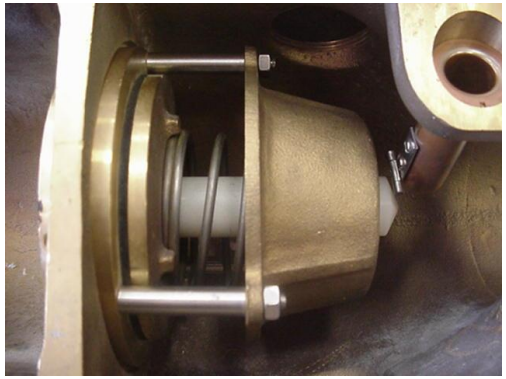


Low Pressure

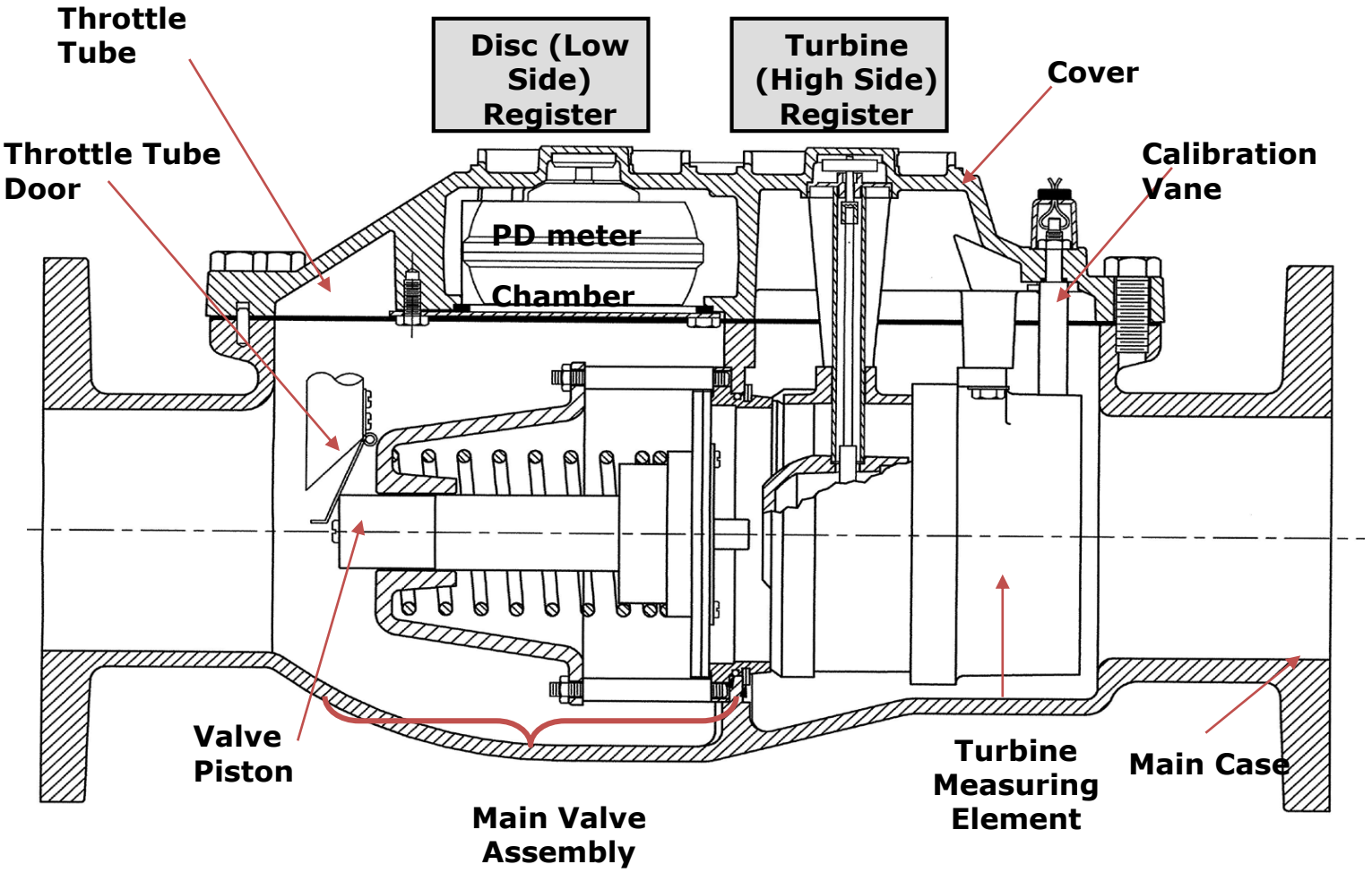
Low Flow

Compound Meter Components

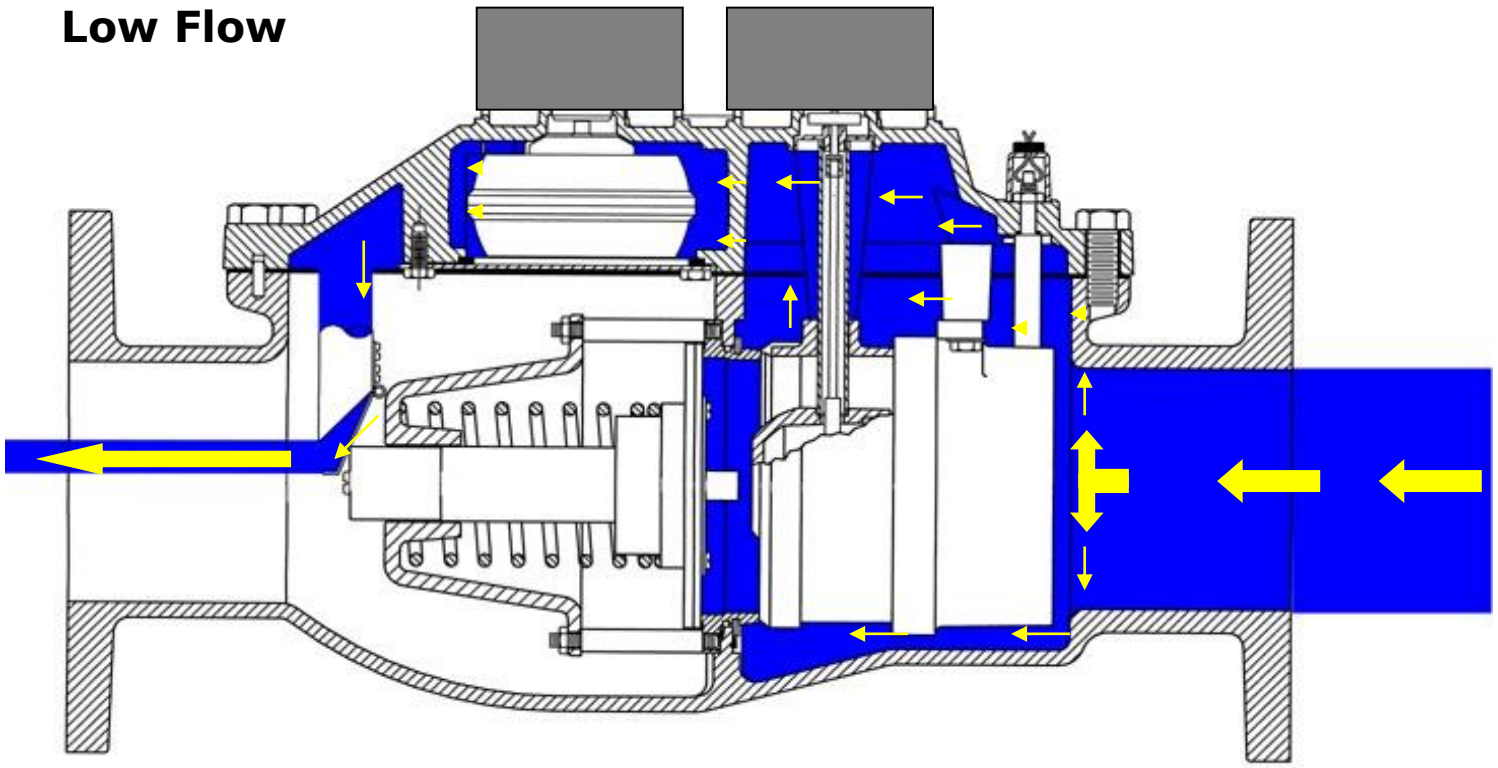




Compound Meter Diagram



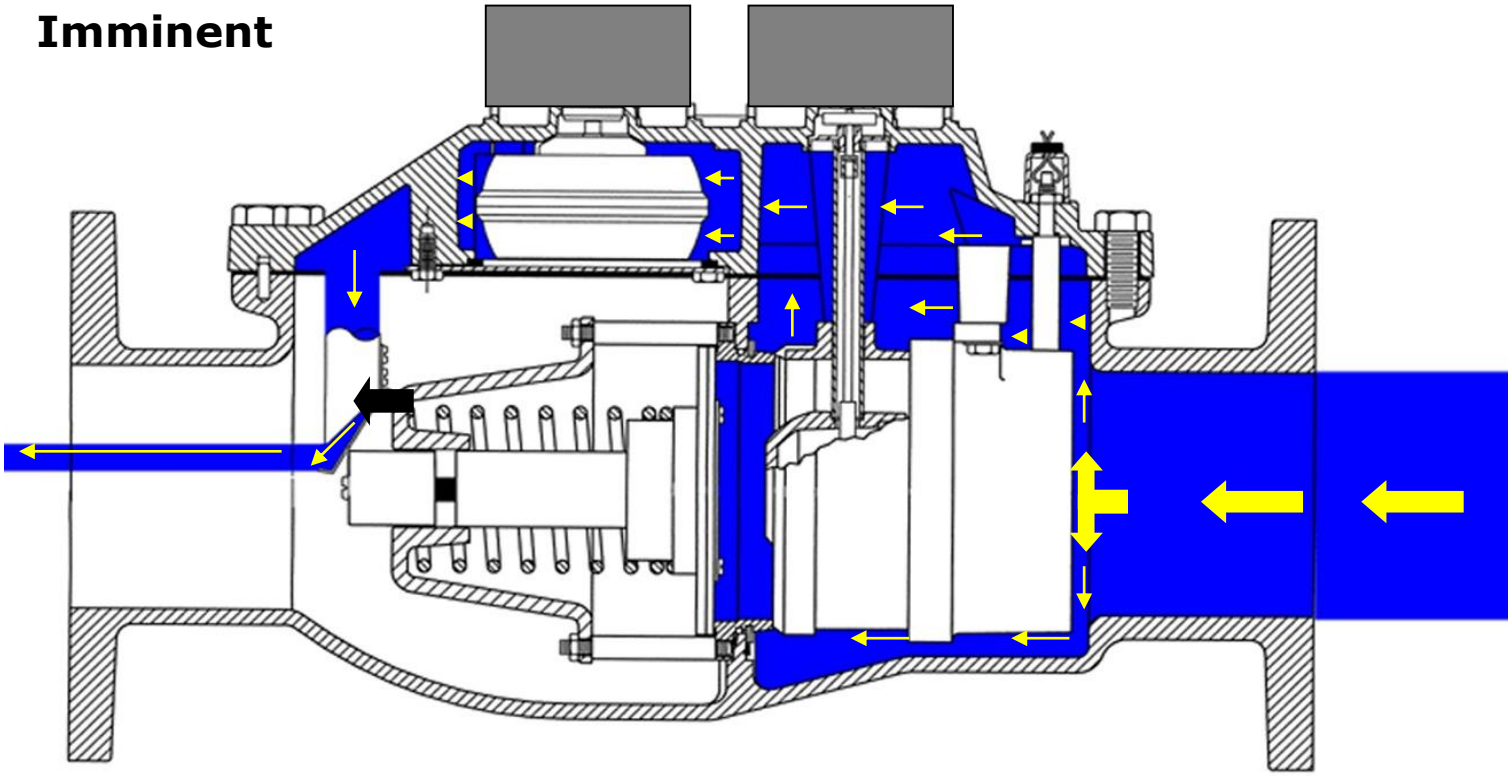
Compound Meter Operation



At low flow, the main valve prevents water from flowing through the Turbine element. All water is diverted through the cover, into the PD meter chamber and out the throttle tube.

Compound Meter Operation

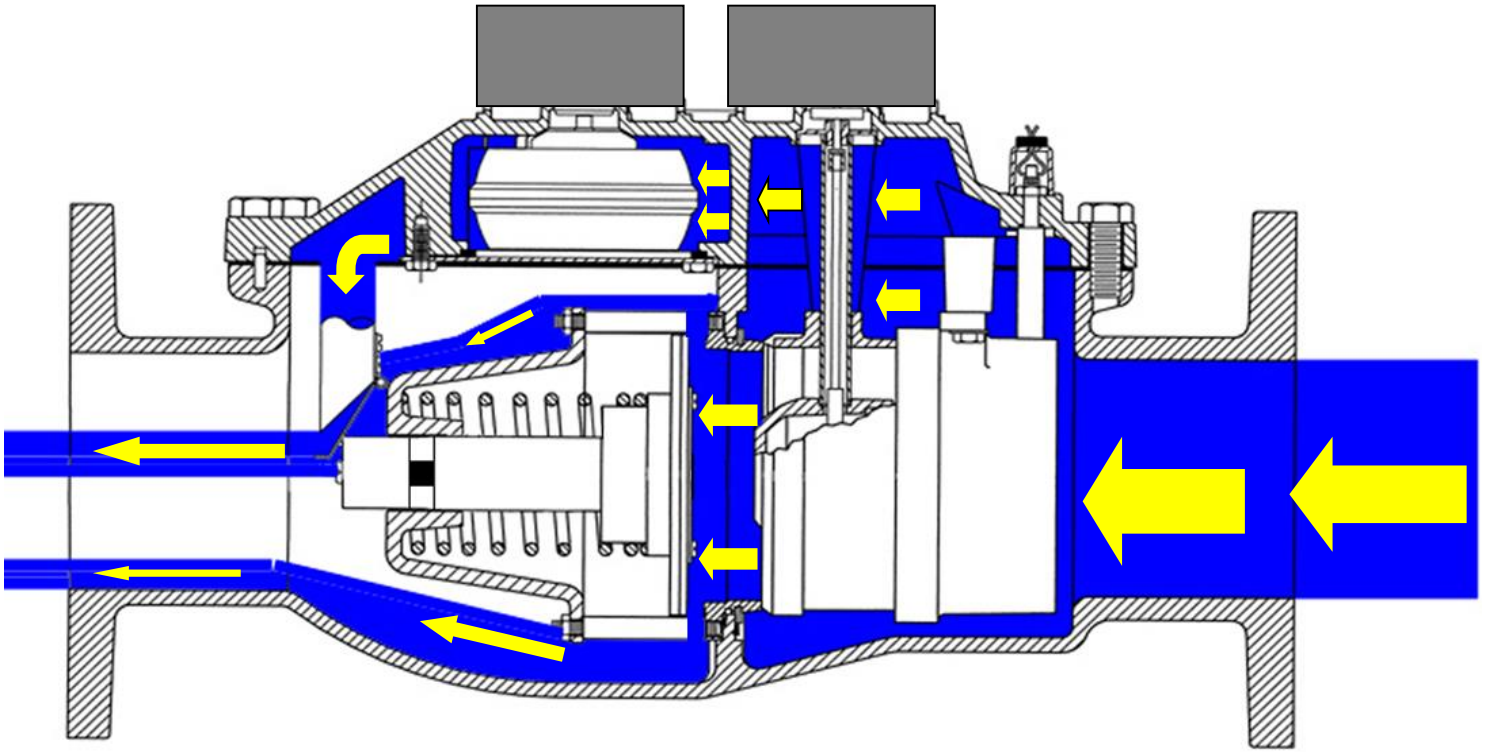
Crossover Imminent



As the flow rate increases, the increased pressure differential causes the valve piston to move rearward, closing the throttle tube door, reducing the flow through the PD meter chamber.

Compound Meter Operation

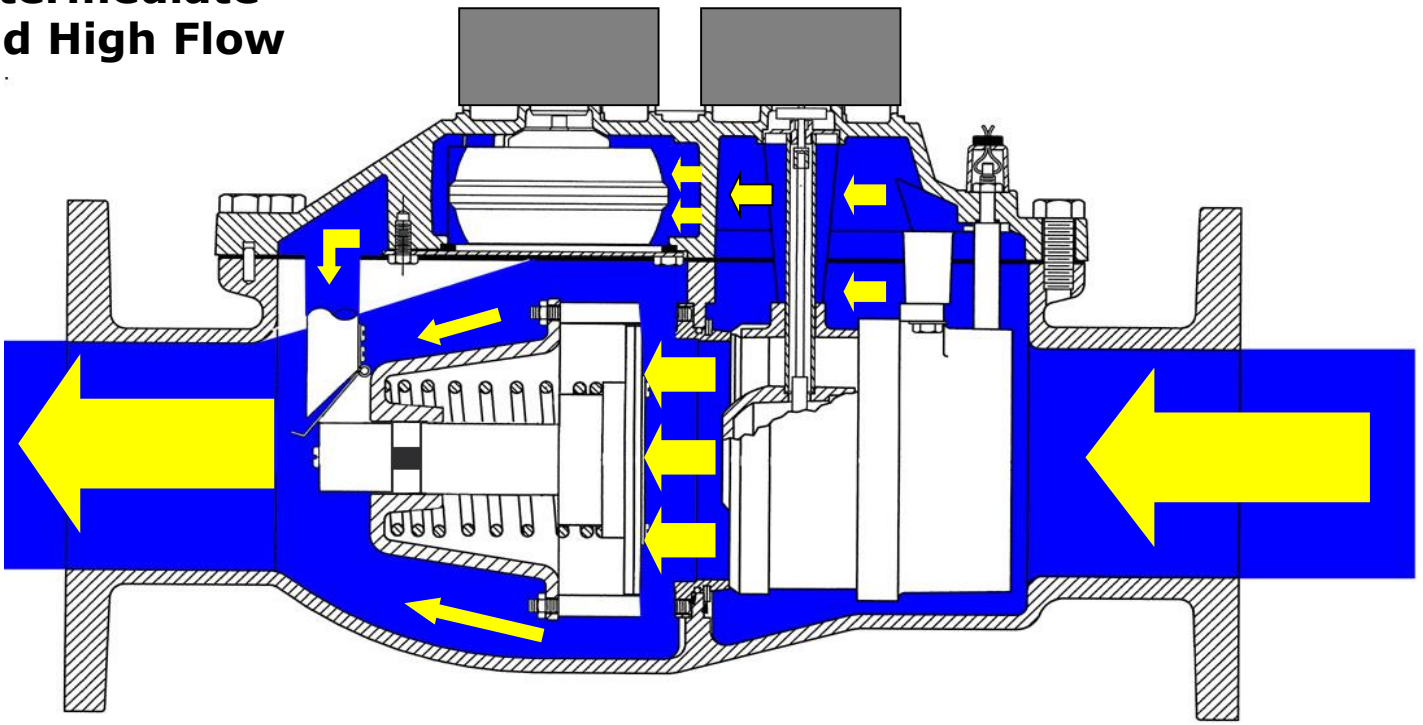
Crossover



The actuation of the valve piston and the subsequent reduction of flow through the PD meter chamber “shunts” a large volume of water through the turbine measuring element forcing the main valve open. Both the turbine and the PD meters are operating.

Compound Meter Operation

Intermediate and High Flow

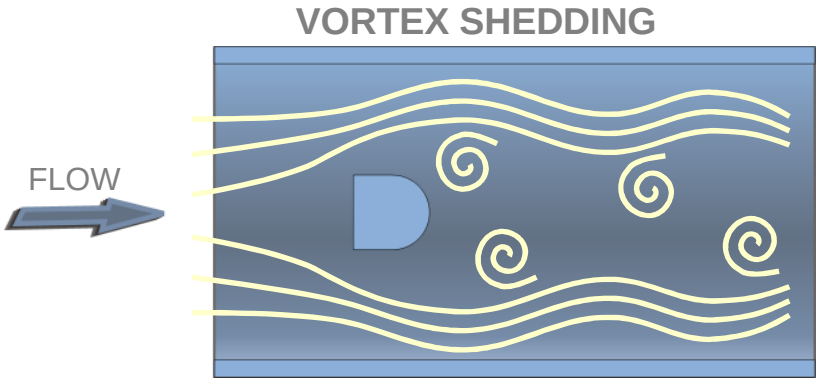


At intermediate and high flow rates, the main valve is fully open and the majority of the water flows through the turbine. Water continues to flow through the PD meter at a greatly reduced rate. This helps “flush” the the PD meter while simultaneously insuring that it does not “over-speed”

Compound Meter

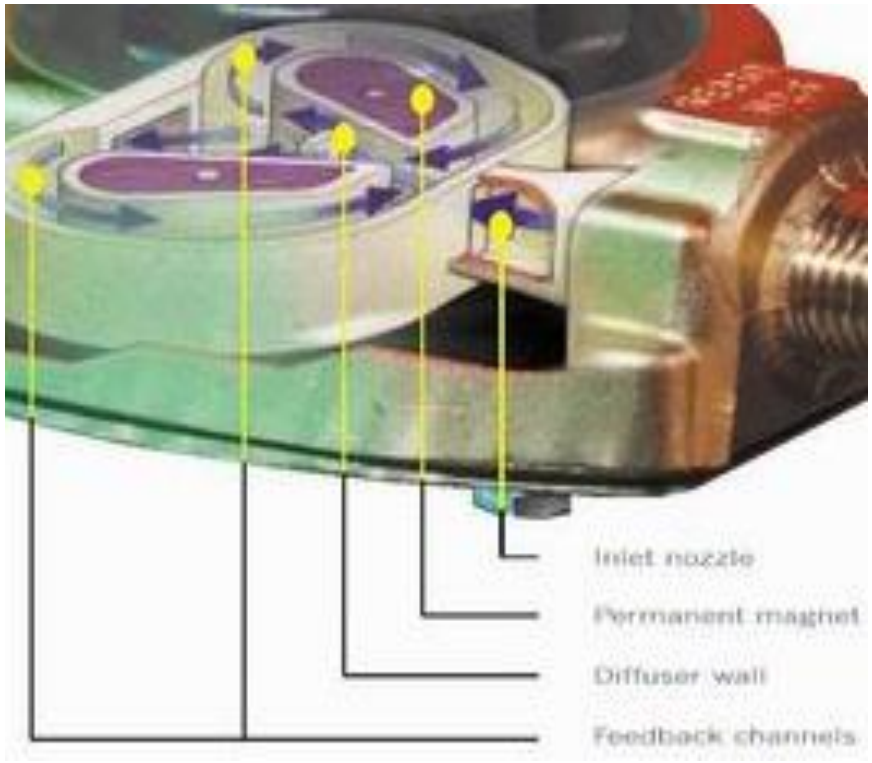
Fluidic Oscillator Meter

- Fluidic oscillators works on the vortex meter principle.
- When a fluid passes by the obstruction, oscillations occur.
- Increasing flow increases the frequency of oscillation.
- A sensor detects the oscillations and an electronic transmitter generates a flow measurement signal.
- Examples of these oscillations in nature:
  - The swirls produced downstream of a rock in a rapidly flowing river
  - waving of a flag in the wind
- Aka: solid state meters.



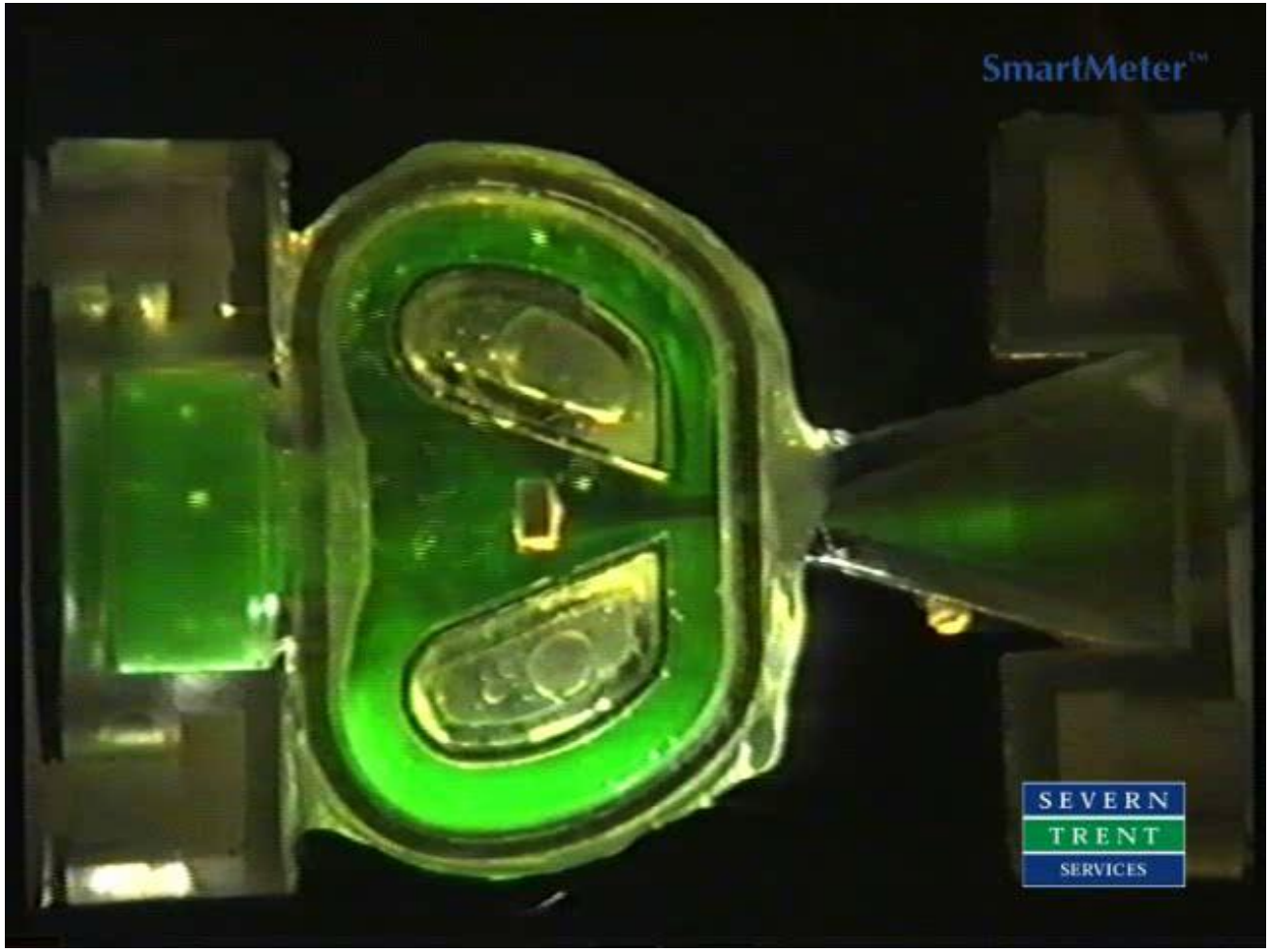
Fluidic Oscillator Meter

Water enters the fluidic oscillator through a nozzle that forms an accelerated jet. When the jet enters the flow chamber, it will initially be drawn to one of the two diffuser walls. The jet will travel along the wall and then exit the flow chamber. At this point, a small portion of the flow will be caught in the feedback channel and be returned to the base of the incoming jet. This causes the jet to flip to the other side of the chamber, where it will travel along the other diffuser wall, and a small amount of water will be returned via the other feedback channel to repeat the process.



This oscillation between the diffuser walls continues while flow is present and its frequency is related to the rate of flow through the chamber. The oscillation is monitored by electrodes placed next to each diffuser wall. An electrical current is induced in the jet by a pair of powerful magnets within the flow chamber. The electrodes sense the induced current, from which the rate of oscillation is calculated and thus, over time, a measure of total flow is derived.

Fluidic Oscillator Meter



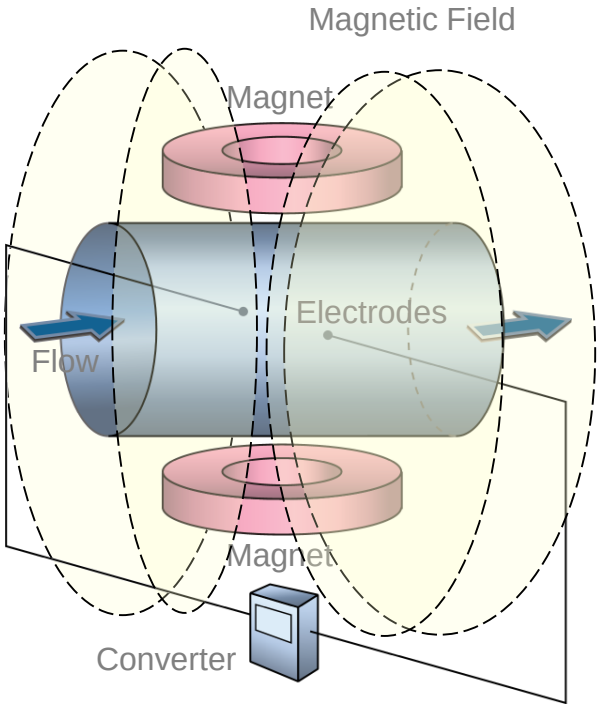
Electromagnetic Measurement

Use Faraday's Law to determine the flow of liquid in a pipe.

Magnetic field is generated and channeled into the liquid flowing through the pipe.

Flow of a conductive liquid through the magnetic field will cause a voltage signal to be sensed by electrodes located on the flow tube walls.

When the fluid moves faster, more voltage is generated. Faraday's Law states that the voltage generated is proportional to the movement of the flowing liquid.
The electronic transmitter processes the voltage signal to determine liquid flow.



Electromagnetic Meters

- **Advantages**
- Measuerment independent of process pressure and temperature
- Large nominal diameter range (DN 2 to 3000)
- No moving parts
- No pressure loss
- No strainer required
- High accuracy, repeatability and long-term stability
- Measure liquids with entrained solids

- **Disadvantage**
- Relatively expensive for small and minimum size meters
- Power Supply
- Deposits on measuring tube or electrodes can cause errors

Ultrasonic Meters

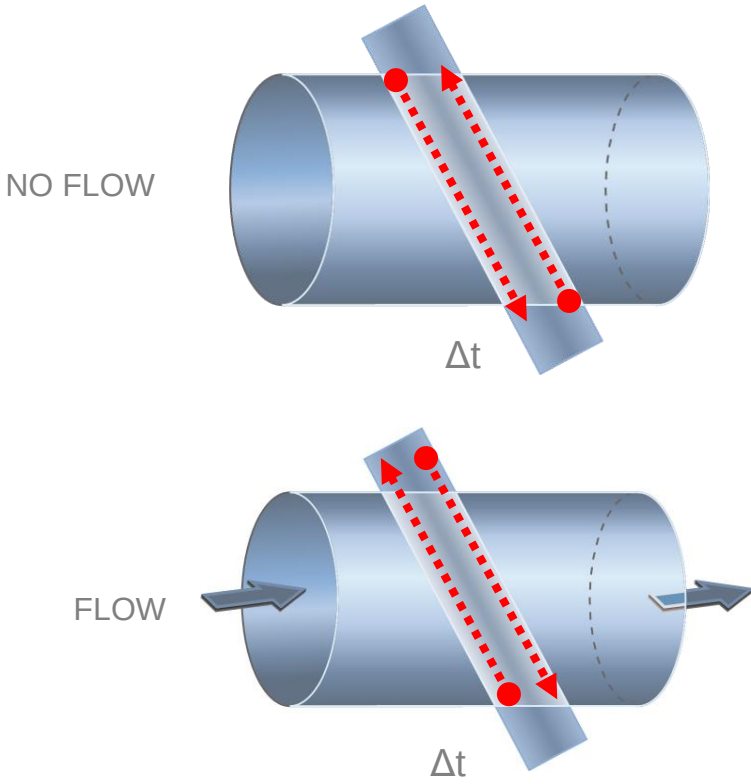
Ultrasonic (transit time) flowmeters send and receive ultrasonic waves between transducers.

At no flow conditions, it takes the same time to travel upstream and downstream between the transducers.

Under flowing conditions, the upstream wave will travel slower and take more time than the (faster) downstream wave.

When the fluid moves faster, the difference between the upstream and downstream times increases linearly.

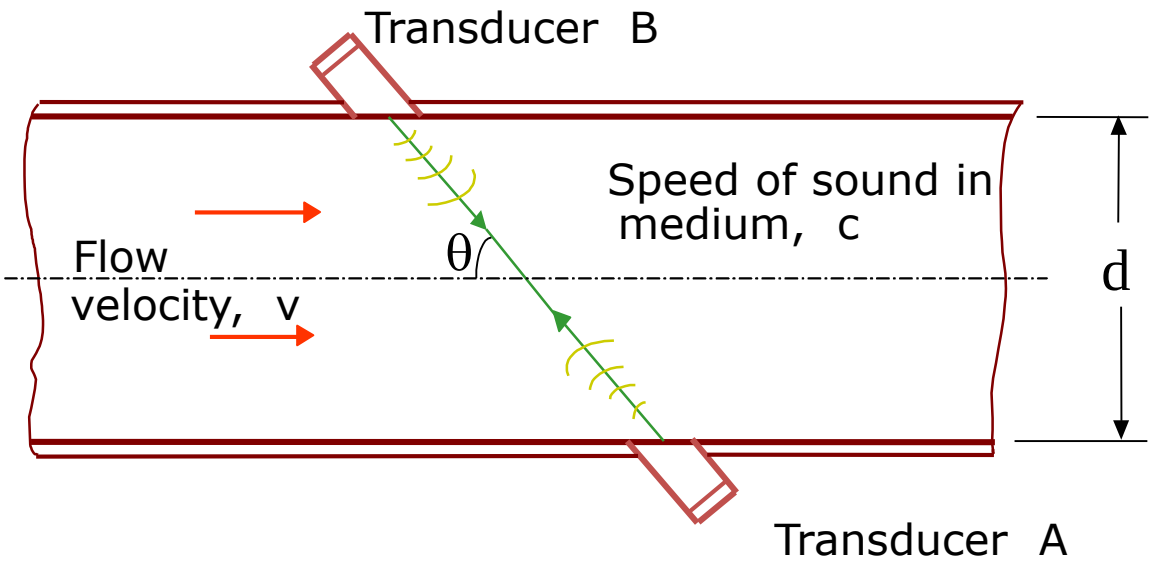
The electronic transmitter processes upstream and downstream times to determine the flow rate.



Ultrasonic Meters

APPLICATION:

High flow rate. Popular for natural gas but not for water application



Principle of operation of a time of flight ultrasonic flow measurement

ULTRASONIC FLOW METER: Clamp-on Systems

- Ideal for flow measurements in existing installations
- For process monitoring dedicated to a specific configuration
- For wide diameter range

  DN 50 – 3000 mm (2” – 120”)
- Also for product identification

Water Meters

Questions or Comments