DOMESTIC WATER METERS

PAKISTAN WATER OPERATORS NETWORK

(March-2022)

PREFACE

On behalf of All water utilities in Pakistan PWON is thankful to JICA for providing Support for ***Management of Water & Sanitation Services in Punjab against Covid-19*** through which lectures / webinars were arranged January 2022, to end March 2022, for ***Better Management of Water & Sanitation Services during Outbreak*** as well *as* ***Awareness & Preventive Measures against Covid-19*** *and* ***Preparation of in house Disinfection by Water & Sanitation Utilities.***

On demand of PWON members, lectures for capacity building of utilities in Pakistan about various important technical topics were also added along with above lectures / webinars / seminars. All these events were well participated and appreciated by all utilities

On demand of member utilities PWON has published these lectures for capacity building and references for improvement of their day to day working for the benefit of their consumers at large. This book on the topic of **DOMESTIC WATER METERS** is published by PWON for the benefit of all its members.

PWON is thankful to Capt. (R) Muhammad Hafeez for Preparing this valuable document.

(Syed Zahid Aziz)
CHAIRMAN
PWON, Pakistan

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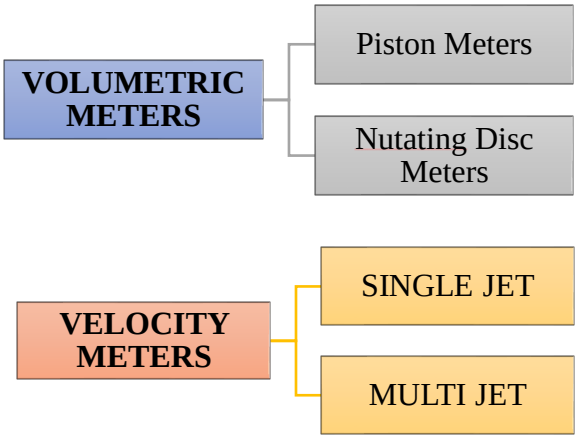
1 Consumer Water Meters

1.1 Main Categories

1. Mechanical Meters

2. Static or Electronic Meters

1.2 Types of Mechanical Meters

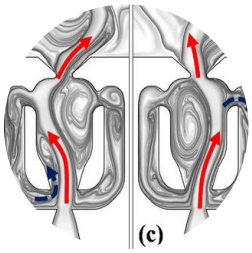


1.3 Types of Static or Electronic Meters

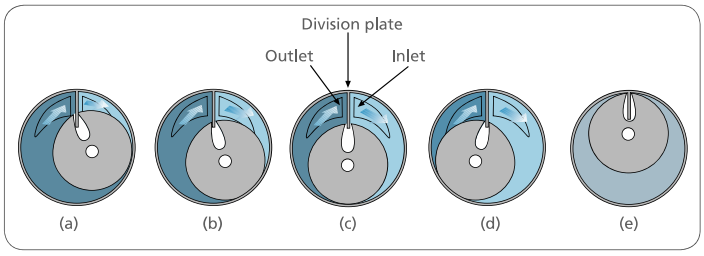
Electromagnetic meters

Ultrasonic meters

Fluidic Oscillator



1.4 Volumetric water meters Oscillating Piston



A known volume of water passes through the meter at each stroke or oscillation of a piston. PD meters calculate the volume of water consumed by counting the number of reciprocations or revolutions of the piston.

1.5 Characteristics of Rotary piston Meters

- The meter housing is typically made out **of brass or plastic,** and the internal components from **plastic**.
- Rotating piston meters are **sensitive to sand or other suspended solids in the water** that can get stuck between the piston and chamber wall, jamming the meter.
- **Thus, it is important that these meters should only be installed in systems with very good water quality, and they should always be provided with built-in strainers.**
- These are very sensitive to **low flows** and are especially suitable for applications where low flow rates or on-site leakage frequently occur, such as domestic consumers.

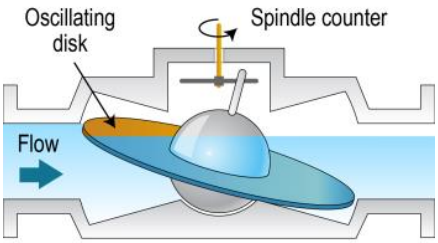
1.6 Characteristics of Rotary piston Meters

- Piston is subjected to wear with age, leakage is possible more easily therefore meters tend to under- register.
- **If air is present in the syst**em, the metering **error can be quite severe** and the wear on the moving parts of the meter is increased substantially.
- It is recommended that an **air valve** is installed at an elevated point upstream of the meter to remove air from the system.
- The main disadvantages of rotating piston meters are that they are sensitive to suspended solids in the water, prone to relatively high-pressure losses.

- Volumetric meters are not sensitive to the velocity profile of the flow entering the meter, and can be installed in virtually any position without significant loss in accuracy. They can also be placed close to bends or pumps

1.7 Nutating Disc Meters

The moving element is a disc that oscillates around the symmetry axis of the chamber, dividing it in separate compartments.



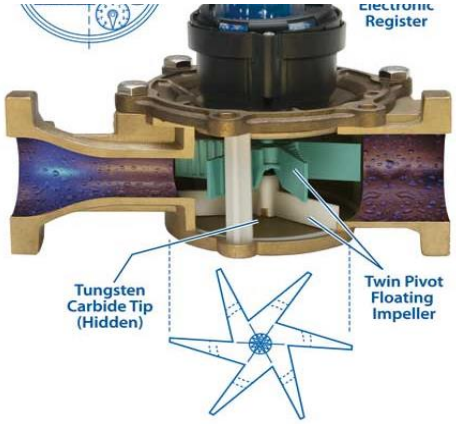
These are common in many countries, especially in North America.

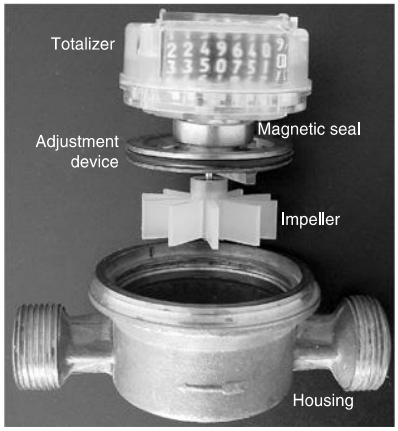
The consumption is determined by counting the number of cycles in which a chamber of known volume is filled and emptied.

1.8 Velocity Water Meters Single Jets

The water is channeled through a *single* jet over a radial-vane impeller placed inside the body of the meter.

Impeller rate of rotation is proportional to the flow velocity of the water, or in other words, to the circulating flowrate.





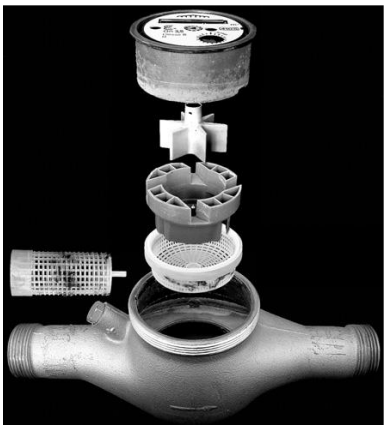
1.9 Single Jet Meters

- **Resistant to suspended solids.**
- **Small and can be installed in tight spaces.**
- **They are generally affected by the installation orientation.** Most single jet meters have to **be installed perfectly horizontally** and upright to ensure accurate measurements (especially at low flows.)

- **Affected by disturbances in the velocity profile.**

1.10 Multijet Meters

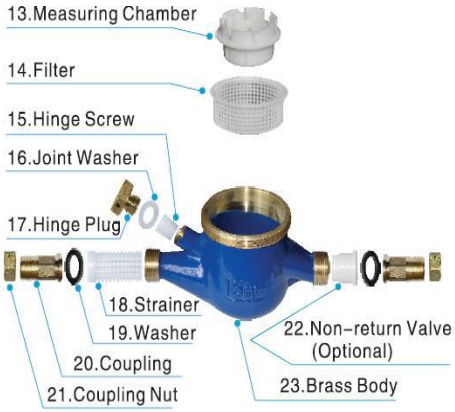
- Similar to single jet meters, except that they use a number of jets to drive the impeller at multiple points. This means that the forces on the impeller are better balanced than in single jet meters



- Water Uniformly Spread Across Multiple Inlet Ports
- Impeller velocity determines flow rate
- Register determines volume
- Comparing meters of equal diameter, multijet meters have a larger housing.
    -

1.11 Parts of Multijet meters

- Strainers on the inlet side of the meter, which can be removed for cleaning.
- A second internal strainer often covers the openings of the meter chamber.



- Multijet meters use an internal bypass with a regulating screw to adjust the flow passing through the impeller.

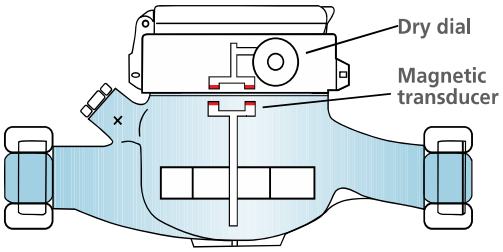
NON-RETURN VALVE

1.12 Horizontal Multijet Meters are Not Suitable for Vertical Installation

METER FOR VERTICAL INSTALLATION

METER FOR HORIZONTAL INSTALLATION

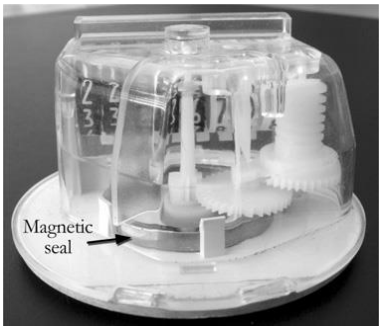
1.13 Why Multi-jet dry type meter not suitable for vertical installation.

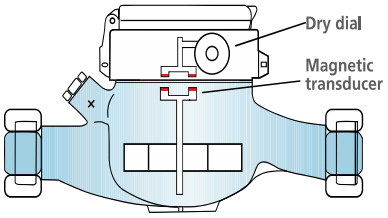


- For Multi-jet dry type meter: The measuring impeller and register are magnetically coupled not directly connected.
- If the meter is installed vertically the distance between the two magnets will change therefore the connecting force of the two magnets will change and can possibly even intermittently lose total connection at higher velocities therefore causing a decrease in accuracy.

2 Dry Type Totalizers

- The reading mechanism hermetically separated from the water flow chamber.
- The counter and indicator are placed in a sealed chamber.
- Dry dial meters often use magnetic transducers, and thus require special protection against magnetic fields that may interfere with the meter reading.





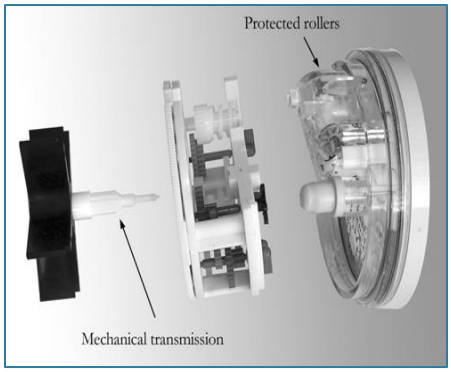
The picture also shows an anti-fraud metallic ring that prevents the manipulation by means of an external magnetic field.

2.1 Advantages & Disadvantages of Dry type totalizers

- Their counters and indicators do not come into direct contact with the water and are thus **protected from suspended particles that may create problems due to settling or obstruction of the counter gears.**
- The transparent window covering the dial doesn't have to be strong enough to sustain the water pressure in the network, which reduces the cost of the meter.
- On the negative side, **if any damp gets past the seal, condensation can form on the inside of the meter window, making the meter impossible to read.**

2.2 Wet dial water meters

- The counter and indicator is either filled with water from the network or housed in a sealed chamber that is filled with a mixture of water and glycerine (to stop algae from growing).



- **A benefit of wet dial meters is that damp is not a problem.**
- **Not suitable for water with particulates.**
- **Transparent window housing has to be strong enough to withstand the full pressure in the distribution network**, adding to the cost of these meters.

- **Better quality meters use 14 mm armour plate glass lenses.**

3 Problems of Mechanical Water Meters

- Mechanical parts are susceptible to effects of sediments and debris, corrosion, scale formation and water chemistry.
- Moving parts in the meters wear out over time. This result in under- registration and loss of revenue with age, particularly at lower flow rates.
- As a result, all mechanical meters should be replaced after a specified period, unless meter testing shows they are still operating to specification
- To maintain performance, mechanical meters require periodically sampled inspection processes, commonly known as meter testing programs.

3.1 Partial Clogging Caused by Suspended Particles

Foreign objects and quality of water
The error curve of most meters, regardless of their technology, may be seriously affected by the quality of the water.

3.2 Debris found within 1-inch size piston meter

Sand & Gravel

Steel pipe corrosion found in meter

3.3 Sand particles damage to piston meter & nutating disc during a test run

Nutating disc

Piston

3.4 lime scale build-up

- **lime scale build-up**
- Excessive build-up of lime scale will influence the rotation of the impeller, even stopping it, leading to a significant under-registration

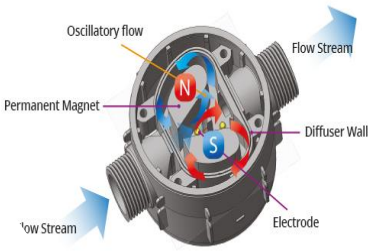
lime scale in a PD meter

Lime scale built-up in the single jet water meter housing

4 ELECTRONIC METERS

No Movi[illegible]Wear Out

Particles Do Not Cause Meters to Stick or Stop. Reduced Pressure Loss

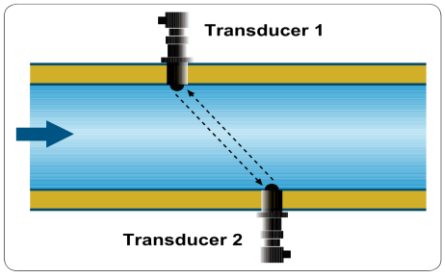


No Maintenance

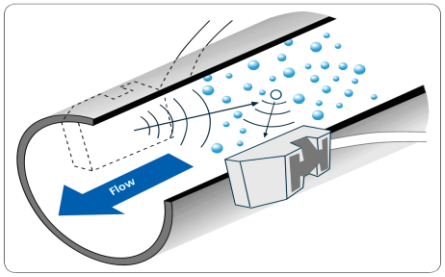
Better Low Flow Accuracy

Better High Flow Durability

4.1 ULTRASONIC FLOWMETERS



- Ultrasonic meters simply measure water by sending an ultrasonic signal in the upstream direction and another in the downstream direction.
- The time for the signal to go upstream is slower than downstream. The time difference is then used to calculate the flow rate and total amount of water flowing.



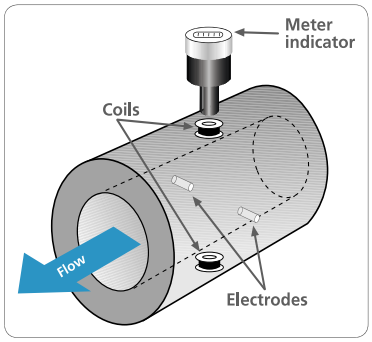
4.2 Ultrasonic meters

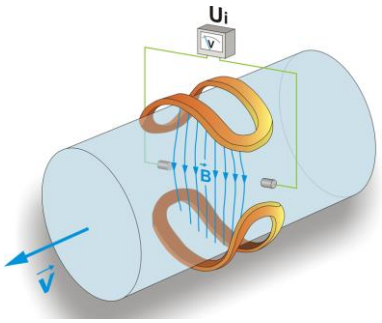
- Have no moving parts and require almost **no maintenance**.
- Highly accurate if installed on favorable conditions. **Excellent low-flow accuracy**.

- These meters may have problems measuring fluids with **suspended solids, debris, or air bubbles, which interrupt the path of the sound signal.**
- **Ultrasonic meters are sensitive to disturbances in the flow, and require significant lengths of straight pipe upstream and downstream of the meter.**

4.3 Electromagnetic meters

- Uses Faraday's Law of Electromagnetic Induction
- A magnetic field is created across the pipe.
- When water, which is an electrical conductor, moves through the magnetic field, a voltage is induced that is detected by electrodes in the body of the meter.
- The voltage is directly proportional to the flow velocity, which allows the flow rate to be calculated.





Electromagnetic meters

- *Magmeter* performance is not affected by temperature, pressure, or viscosity. These meters can handle rapid changes in flow.
- They can accurately measure clean fluids like drinking water or those with heavy solids like sewage.

- Excellent low-flow accuracy with just one or two upstream or downstream straight run requirements.

4.4 Fluidic Oscillator Meters

- Based on Bernoulli's Theory - A slow-moving high-pressure gas becomes fast moving low pressure gas at the nozzle exit forming a jet of gas.

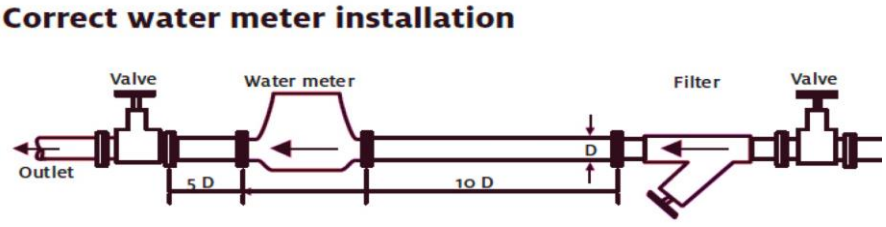
In short:-

• Meter Design Generates Oscillations

• Electrodes Count Oscillations

• Higher Flow Rate = More Oscillations per Time Period.

5 GENERAL RECOMMENDATIONS FOR INSTALLATION OF METERS.



- **In utilities where interruptions of the supply are common, or in elevated positions, where trapped air may be found, it is convenient to install air valves upstream from the meter**
- **As Non-return valve is demanded in built** in water meter therefore only a shutoff valve is required before meter.
- **A strainer** before meter may be beneficial due to particles in our water supply system.
- A **shutoff valve** on downstream of meter is also demanded in certain Utilities to isolate house from water meter for maintenance.

6 Water Meters Calibration Methods

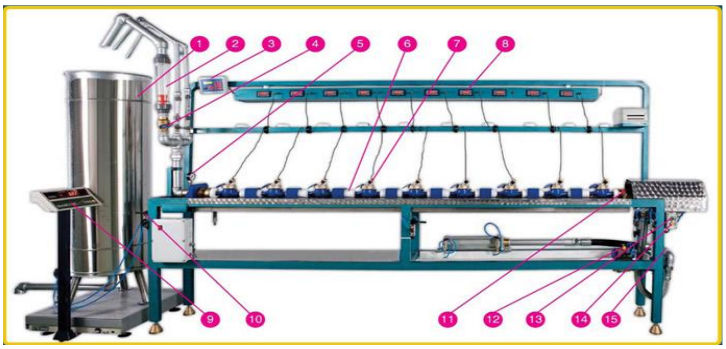
TEST METHODS:

- Calibrated Tanks (Volumetric Method),
- Reference Flow meter (Comparative Method)
- Weighing Scales (Gravimetric Method).

Gravimetric system.

- In the gravimetric system, the water passed through the water meter is collected in the water tank and its weight is measured by the weighing scale placed under the tank.

- The measurement error percentage is calculated by comparing the value of volume taken from the water meter display and his value taken from the weighing scale.



6.1 Volumetric & Comparative Method

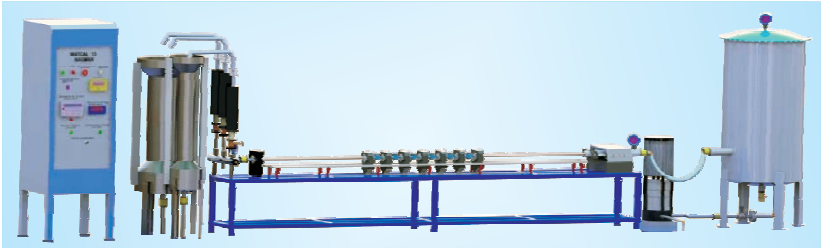
- **Volumetric Method:**

  The calibration method is to drive a known volume of fluid through the flow meter at a given rate.

  That volume of water collected in a tank is compared with water meter reading

- **Comparative Method**

  Calibrated master meter is installed in line with the meter being tested. The meter can be left in place for some time before comparing the volumes through the two meters. This is an accurate method



7 Major International Metering Standards

(1) Organization International de Métrologie Légale

International Organization of Legal Metrology (OIML)

OIML R49-1 (Metrological and technical requirements)

OIML R49-2 (Test methods)

OIML R49-3 (Test Report Format)

(2) International Standards Organization (ISO)

ISO 4064 Part 1 (Specifications)

ISO 4064 Part 2 (Installation Requirements)

ISO 4064 Part 3 (Test Methods and equipment)

(3) **Measuring Instruments Directive (MID)** 2004/22/EC **of European Parliament and of Council. (Harmonized with other standards in 2014).**

Annex MI-001

(4) **American Water Works Association (AWWA)**

AWWA C 700 (PD Meters), AWWA C 712 (Fluidic Oscillator Meters)

AWWA C 708 (Multi-Jet Meters), AWWA C 713 (Single-Jet Meters)

7.1 ISO & OIML& EN Standards are now identical

- The OIML& ISO websites say; OIML R 49-1:2013 (E) –was developed by a joint OIML/ISO/CEN working group. The content is the same in substance as that of ISO 4064-1:2014 Water meters for cold potable water and hot water.
- The combined standard is now referred as,
- ISO 4064:2014|OIML R 49:2013 or ISO4064(OIML R 49)
- **European standard EN 14154 is now BS EN ISO 4064-1:2017 which is same as ISO 2014 & OIML 2013**
- So practically there is only OIML & ISO covering all standards of water metering

Sr.No	Standard	Membership (as of 2021)	Headquarters
1	**ISO 4064:2014 / OIML R 49:2013**	**162 countries** are members of ISO and **62 members & 65 corresponding members of OIML**	OIML has Its head office In **Paris.** ISO central secretariat at Geneva Switzerland

2	**MID (measuring Instrument Directive) OF European Parliament & Council**	**31** countries are members	Passed by EU Parliament Brussels
3	**AWWA**	AWWA currently has more than 50,000 members, including 4,700 utility members	Denver, USA

7.2 International Standards Applicable Now in the World

8 TEMPERATURE AND WATER PRESSURE

8.1 Now the Temperature Classes (Cold & Hot) as per OIML /ISO4064-2014

Overload water temperature

- A water meter with MAT ≥ 50 °C shall be capable of withstanding a water temperature of MAT + 10 °C for 1 h. The test is specified in OIML R 49-2:2013.

Table 1 Meter temperature classes

Class	mAT °C	MAT °C
T30	0.1	30
T50	0.1	50
T70	0.1	70
T90	0.1	90
T130	0.1	130
T180	0.1	180
T30/70	30	70
T30/90	30	90
T30/130	30	130
T30/180	30	180

mAT: Minimum admissible temperature
MAT: Maximum admissible temperature

8.2 Cold Water Meters Temperature Classes ss per ISO & OIML

CLASS	MINIMUM ADMISSIBLE TEMPERATURE °C	MAXIMUM ADMISSIBLE TEMPERATURE °C	Overload water temperature test CLASS 7.6
T30	0.1	30	
T50	0.1	50	MAT +10 °C ± 2.5 °C for a period of 1 h after the meter has reached temperature stability. T 50 class will be capable of bearing temperature 57.5 to 62.5 °C for one hour.

8.3 MID 2014/32/EU TEMPERATURE RANGES

The values for the temperature range shall fulfill the following conditions:

0.1°C to at least 30 °C, or 30 °C to at least 90 °C.

The meter may also be designed to operate over both ranges.

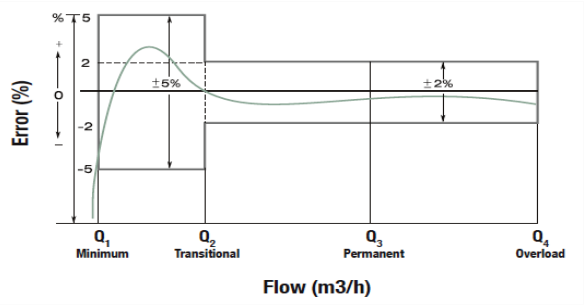
8.4 Water Pressure: OIML/ISO &MID

- **Pressure range**
- 0.3 bar to at least 10 bar
- **Pressure loss**
- **The pressure loss through a water meter, including its filter or strainer and/or straightener,** where either of these forms an integral part of the water meter, **shall not be greater than 0.63 bar** between *Q*1 and *Q*3.
- **The pressure loss class is selected by the manufacturer** from the values in Table

Class Delta Pc	Maximum pressure loss Bar
Δp 63	0.63
Δp 40	0.40
Δp 25	0.25
Δp 16	0.16
Δp 10	0.10

8.5 OIML/ISO & European Standard ACCURACY REQUIREME

- **Accuracy class 2 water meter**
- The MPE for the upper flow rate zone ($Q2 \leq Q \leq Q4$) is ±2 %, for temperatures from 0.1°C to 30 °C, and ±3 % for temperatures greater than 30 °C.



- The MPE for the lower flow rate zone ($Q1 \leq Q < Q2$) is ±5 % regardless of the temperature range.

8.6 MID ACCURACY IS SAME AS OF OIML/ISO ClASS-2

- The MPE, positive or negative, on volumes delivered at flowrates between the transitional flowrate (Q2) (included) and the overload flowrate (Q4) is: **2 % for water having a temperature ≤ 30 °C, 3 % for water having a temperature > 30 °C.**
- The MPE, positive or negative, on volumes delivered at flowrates between the minimum flowrate (Q1) and the transitional flowrate (Q2) (excluded) **is 5 % for water having any temperature.**

8.7 METROLOGICAL REQUIREMENTS OIML R 49-1: 2013 (E) /ISO4064-2014

4.1.3 The value of Q_3 , expressed in m^3/h, shall be chosen from the following list:

1	1.6	2.5	4	6.3
10	16	25	40	63
100	160	250	400	630
1 000	1 600	2 500	4 000	6 300

The list may be extended to higher or lower values in the series.

Q2/Q1 shall be 1.6
Q4/Q3 shall be 1.25

MID. The values for the flow rate range shall fulfil the following conditions:
Q3/Q1 ≥ 10, Q2/Q1 = 1.6, Q4/Q3 = 1.25

8.8 Metrological Requirements---Cont. OIML R 49-1: 2013 (E) /ISO4064-2014

- If Q3 is fixed at some value from the table, the greater the ratio of Q3/Q1 the lesser the Q1 & lesser the ratio the greater the minimum flow.
- Normally manufacturers make(OIML/ISO & MID) meters with Ratio of Q3/Q1 as160, 200 & 250 for 15mm class.
- **If we choose Q3 as 2.5 and Q3/Q1® as 160 the Q1, minimum flow will be 15.6 liters/hr.**
- **NMI (National Measurement Institute, Australia) says as follows;**
- **For 15 mm and 20 mm meters the minimum value of Q3/Q1 shall be 200.**
- **If we choose Q3 as 2.5 and Q3/Q1as 200 the Q1will be 12.5 liters/hr.**

8.9 COMPARISON OF VARIOUS STANDARDS (15mm cold water meters Multijet type)

Standard	Minimum Flow l/h Q1	Permanent Flow Q3		Overload Flow /h Q4	Pressure range bar	Temperature range °C	Accuracy requirement	Remarks
OIML/ISO	**15.6**	**2.5**		**3.125**	**0.3-10**	**0.1-30 0.1-50**	**lower flow rate zone ±5 % upper flow rate zone ±2 % for meters up to 30 °C±3 % for greater than 30 C**	**Q3/Q1=160 Q4/Q3=1.25**
MID	**15.6**	**2.5**		**3.125**	**0.3-10**	**0.1-30**	**lower flow rate zone ±5 % upper flow rate zone ±2 % for meters up to 30 C ±3 % for greater than 30C**	**Q3/Q1=160 Q4/Q3=1.25**
AWWA C708	**60**	**2.3**		**4.5**	**10**	**27**	**lower flow rate zone±3 % upper flow rate zone±1.5%**	**Q3/Q1=38 Q4/Q3=1.95**

Water temperature range up to 50C is only available in OIML/ISO.
Minimum flow of AWWA is 60 l/h which may not be suitable for our conditions.

8.10 METERS CERTIFICATION

- OIML is the only organization which covers detailed specifications (Meteorological and test procedures) and issues test certificates through notified bodies approved centrally by OIML.
- MID covers only essential requirements for water meters, it does not cover detailed specifications as is in case of OIML and ISO. Type examination certificates are issued by the authorities nominated by the member states.
- ISO does not issue any test certificate. Compliance certification is performed by external certification bodies, which are largely private and are **not nominated by ISO, therefore no control over them.**

8.11 References:

- *JE VAN ZYL: Introduction to Integrated Water Meter Management Edition 1*
- *ISO 4064-1:2014 - Water meters for cold potable water and …*
- *OIML R-49-1,2,3 Edition 2013 (E).https://www.oiml.org*
- *DIRECTIVE 2014/32/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014*
- *Directive 2004/22/EC Directive*