
**GOVERNMENT OF INDIA**

भारत सरकार

**MINISTRY OF RAILWAYS**

रेल मंत्रालय

# Guidelines

# on

# Water Meters

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**Works Directorate**

कार्य निदेशालय

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# INDEX

1. **Water metering: -** Water metering is the process of measuring the water use. Water meter is a device which measures the volume of water flowing through a pipe line system. Generally water meters are provided to measure the volume of water used by residential and commercial buildings that are supplied with water by a public water supply system. Water meters are also used at a water source to determine flow through a particular portion of the system. Normally, water meters measure flow in cubic meters ($m^3$), some electronic meter can also display rate-of-flow in addition to total usage.

   Water meters can be classified according to the technology used for their functioning. The choice depends on the flow measurement method, the type of end use, the range of flow rates and accuracy requirements in measurements.

2. **Type of Water meter:-** Water meters can either be mechanically driven or sensor based with each having specific attributes to suit various operating conditions. A brief overview is provided below:

### 2.1 Mechanical meters:-

Mechanical meters are positive displacement flow meters. They operate by isolating and counting known volumes of a fluid, while feeding it through the meter. By counting the number of passed isolated volumes, a flow measurement is obtained. These meters are suited for measurement of clear water with little turbidity and generally less expensive than non-mechanical types. Hence these are commonly used in urban water supply systems. However, they have a higher maintenance requirement.

### 2.2 Electromagnetic meters:-

Electromagnetic meter is a non-mechanical meter mainly used in urban or wastewater and industrial systems. This is also known as magflow meter. Technologically these are velocity-type water meter, except that they use electromagnetic system for determining the water flow velocity. Mag meter uses the principle of Faraday's law of induction for measurement, and require AC or DC electricity from a power line or battery to operate the electromagnets. Since Mag meters have no mechanical measuring element, they normally have the advantage of being able to measure flow in both direction, and use electronics for measuring

and totalizing the flow. Magmeters can also be useful for measuring raw (untreated/unfiltered) water and waste-water, since there is no mechanical measuring element to get clogged or damaged by debris flowing through the meter.

### 2.3 Ultrasonic water meter:

Ultrasonic water meter uses an ultrasonic transducer to send ultrasonic sound waves through the fluid to determine the velocity and translate the velocity into measurement of the water volume. The ultrasonic meter has a sensor that can be either inserted inside, or attached outside of the pipe. The sensor measures the water velocity in the pipe, and then converts this into flow rate.

## 3.0 Salient features of a water meter

## 3.1 Mechanical Water Meter

### 3.1.1 Working Principle:

An impellor is rotated by water passing through the meter. The rotation of impeller is then translated into a volumetric reading. The mechanism is calibrated by an adjustable device that is preset and security sealed. These meters are available in various sizes and require full water flow in the pipeline during measurement.

### 3.1.2 Advantages of Mechanical meter:

- These are reliable and provide reasonably accurate means of measurement provided meter is correctly installed.
- The initial cost is relatively low.
- The in-line maintenance is simple.

### 3.1.3 Disadvantages of Mechanical meter:

- Mechanical parts can be damaged, making frequent accuracy testing necessary.
- Prone to wear in silty water, resulting in loss of accuracy and frequent need for replacement.
- Some head loss possible.

- Short service life.

### 3.1.4 General Features of Mechanical Water Meter *:*

- The meter should be leak proof and totally sealed in metallic outer body.
- It should be repairable without interrupting water supply.
- It should have removable mechanism which ensures easy maintenance.
- Impeller should be protected by temper proof metallic cover.
- Reliable sensitive metrology and low pressure loss.

**Technical Features**: These meters should conform to ISO: 4064-2005 (Revised in 2014). The general parameters as per ISO: 4064 are reiterated below:

| **Size of meter** | **Unit** | **150 mm** | **200 mm** | **250 mm** | **300mm** | **400mm** | **500mm** |
|---|---|---|---|---|---|---|---|
| **Minimum flow Q min** | m3/h | 4.50 | 7.50 | 12 | 18 | 30 | 45 |
| **Nominal flow Qn** | m3/h | 150 | 250 | 400 | 600 | 1000 | 1500 |
| **Maximum flow Q max** | m3/h | 300 | 500 | 800 | 1200 | 2000 | 3000 |
| **Minimum Reading** | m3 | .0002 | .0002 | .0002 | .0002 | 0.1 | 0.1 |
| **Maximum Reading** | m3 | 7 digits | 7 digits | 8 digits | 8 digits | 8 digits | 8 digits |
| **Temperature Suitability.** | ºC | 50ºC | | | | | |
| **Working Pressure** | Mpa | <1.6 Mpa | | | | | |

**Mechanical Flow Meter**

## 3.2 Electromagnetic meter:-

### 3.2.1 Working Principle:

Electromagnetic flow meters do not have any moving part and are minimally affected by flow disturbances related to viscosity or density. These flow meters use Faraday's Law of Electromagnetic Induction. In Electromagnetic flow meters, the magnetic field is generated by a set of coils. As the conductive liquid passes through the electromagnetic field, an electric voltage is induced in the liquid, which is directly proportional to its velocity. This induced voltage is perpendicular to both the liquid flow direction and the electromagnetic field direction as per Fleming's right hand rule. The voltage sensed by the electrodes is further processed by the transmitter to give standardized output signal or displayed in appropriate engineering unit. The flux density of the electromagnetic field in a given flow meter and the distance between the electrodes are constant. Therefore, the induced voltage is only a function of liquid velocity.

The induced voltage is not affected by the physical properties of liquid like temperature, viscosity, pressure, density and conductivity, as long as conductivity of the measured liquid is sufficient and above the minimum threshold level. For reliable measurement, the pipe should be completely full of liquid and the electrical conductivity of liquid under measurement should have minimum of 5 micro siemens per cm. of conductivity. This flow meter does not obstruct flow, so it can be applied to clean, sanitary, dirty, corrosive and abrasive liquids.


**Electromagnetic Flow Meter**

### 3.2.2 Advantages of Electromagnetic flow meter:

- Electromagnetic flow meter does not have moving parts, and no obstruction of fluid flow throttle parts, so when the fluid passage does not cause any additional pressure loss, and it does not cause such wear, blockage, in particular for measuring water with silt or solid particles.
- Electromagnetic flow meter is kind of volume flow measuring instruments. Besides this, during the measurement process, it can also measure temperature of the medium, viscosity, density and electrical conductivity.
- Electromagnetic flow meter measured only the average velocity. It is not affected by state of flow (laminar or turbulent).

### 3.2.3 Disadvantages of Electromagnetic flow meter:

- Require Power supply
- Electronic components are more vulnerable to damage.
- Repairs require skilled technician and specialized equipment.

### 3.2.4 Type of Electromagnetic flow meter & their Technical Details:

The Electromagnetic flow meter is of better performance and reliability. Normally, two types of Electromagnetic flow meter are available in the market:

**A.** Flange type Electromagnetic Flow meter
**B.** Insertion type Electromagnetic Flow meter

### A. General Features of Flange type Electromagnetic Flow meter:

This flow meter is installed in straight pipe line by doing necessary plumbing work. A relatively short straight length of pipe is required for installation of this flow meter in comparison to mechanical meters. The LCD display in the converter makes it easier to take readings. Parameters can also be set up using infrared touch knobs without opening the cover of convertor. These flow meter are available in market in two types i.e. Integral and Remote type. In Integral type flow meter, the converter is integrally installed with flow meter body while in remote type, the measuring unit (sensor) is installed with the water supply pipe and converter unit is placed at another place/station and connected by wires.

**Salient features of flow sensor:**

| **Parameters** | **Specifications** |
|---|---|
| Size | DN10~DN3000mm (DN- Nominal dia) |
| Nominal Pressure | 0.6~4.0 MPa |
| Accuracy | ±0.5% of reading, ±0.3% or 0.2% available |
| Line material | Teflon,PFA,F46,FEP,Neoprene,Polyurethane,etc. |
| Electrode Type | General Type, Scraper Type and Replaceable Type |
| Electrode material | SS316, SUS316L, Hastelloy-B, Hastelloy-C, Titanium, Platinum-iridium, Stainless steel covered with tungsten. |
| Structure Type | Integral type, Remote Type |
| Ambient Temperature | -25$^0$C~+60$^0$C |
| Ambient Humidity | 5~100%RH (relative humidity) |

| | |
|---|---|
| Medium Electrical Conductivity | ≥5 µS/cm |
| Measuring Range | 1500:1, flow velocity ≤10m/s |
| Protection Class | IP65 (dustproof and watertight), IP68 (dustproof and submersible for a prolonged period of time, optional, available only for remote type). |

**Integral Electromagnetic Flow meter**

**Remote Electromagnetic Flow meter sensor**

**Salient features of Converter:** Signal Converter adopts embedded 16-bit micro-controller. The convertor, converts the signals received through sensors fitted with supply pipes. The converter is embedded with the function of bi-directional measurements, forward & reverse accumulated and difference in values.

| **Parameters** | **Specifications** |
|---|---|
| Power Supply | AC220Volts 50 Hz, DC24Volts |
| Power Consumption | <20W |
| Display & Push Buttons | 3 Line LCD Display with back lighting displays %age of flow, instantaneous flow, total flow & alarm status |
| Accuracy | ±0.5% of reading, ±0.3% or 0.2% available |
| Damping time | Adjustable between 0.5 and 199.9 seconds |
| Protection class | IP65/IP67 (dustproof and submerging for short times) |

| | |
|---|---|
| Lighting protection | 12KV, 1000A, equipped with lighting arrester in the power source and external input and output terminals |
| Power Failure | Retains data records of totalized value when pulse output is used (retention period approx. 10 years) |
| Weight | 3-4 kg Approx. |

**Remote Converter**

## B. General features of Insertion type Flow Meter:

Insertion type flow meters are more suitable for large diameter pipes and where water supply can't be cut off even for smaller period as they do not much require plumbing work. In the insertion type flow meter, the sensor can be installed by sandwiching the meter between two flanges of pipe, without removing the measuring pipe. In addition, it can also be equipped on the old pipe with local hatching. Measurement is independent of fluid density, viscosity, humidity, temperature, and pressure. The sensor with good advanced processing technology and liquid airproof generally has long natural life. In this type flow meter, the measuring unit (sensor) is installed with the water supply pipe and converter unit is placed at another place/station connected by wires.

Insertion type sensor for electromagnetic flow meter is used widely in the applications where the pipe size is relatively large but the high performance price ratio is required.

**Salient features of Insertion type flow sensor:**

| Parameters | Specifications |
|---|---|
| Size | DN300~DN3000mm |
| Nominal Pressure | 1.6 MPa or 16Bar |
| Accuracy | Flow rate – 0.5m/s±0.5<br>Flow rate of full range >1m/s±1.0% |
| Measuring Probe material | Carbon steel,SS304 stainless steel |
| Electrode material | SS316,SUS316L,Hastelloy-B,Hastelloy-C, |
| Electrode Enclosure material | PVC, ABC, Polypropylene, etc |
| Ambient Temperature | -25$^0$C ~ +60$^0$C |
| Ambient Humidity | 5~95% RH |
| Atmospheric Pressure | 86~106 KPa |
| Straight Pipe Length Required | 10D upstream,5D downstream |
| Connection | With Flange |
| Protection Class | IP65(dustproof and watertight),IP68(dustproof and submersible for a prolonged period of time, optional, available only for remote type). |

**Flange Type Insertion Sensor**

**Remote Converter**

**Salient features of Converter:** Signal Converter adopts embedded 16-bit micro-controller. The convertor, converts the signals received through sensors fitted with supply pipes. The converter has the functions of bi-directional way measurement, forward & reverse accumulated and difference in values.

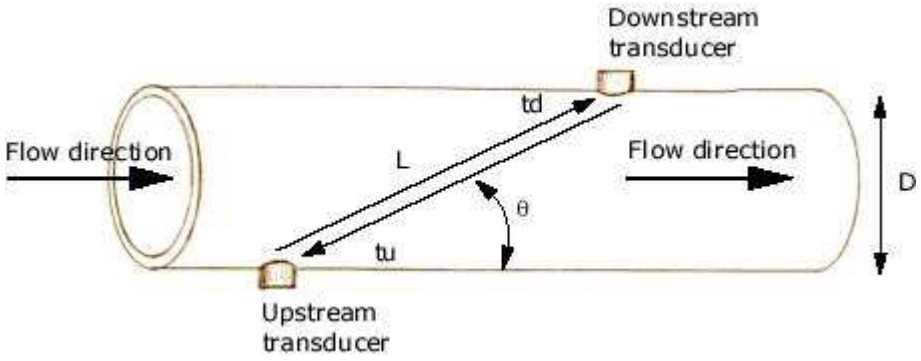
| **Parameters** | **Specifications** |
|---|---|
| Power Supply | AC220Volts 50 Hz, DC24Volts |
| Power Consumption | <20W |
| Display & Push Buttons | 3 Line LCD Display with back lighting displays %age of flow, instantaneous flow, total flow & alarm status |
| Accuracy | ±0.5% of reading, ±0.3% or 0.2% available |
| Damping time | Adjustable between 0.5 and 199.9 seconds |
| Protection class | IP65/IP67 (dustproof and submerging for short times) |
| Lighting protection | 12KV, 1000A, equipped with lighting arrester in the power source and external input and output terminals |
| Power Failure | Retains data records of totalized value when pulse output is used (retention period approx. 10 years) |
| Weight | 3-4 kg Approx. |

3.3 **Ultrasonic water meter: -** An **ultrasonic flow meter** is a type of flow meter that measures the velocity of a fluid with ultrasound to calculate volume flow. At no flow conditions, the frequencies of an ultrasonic wave transmitted into a pipe and its reflections from the fluid are the same. Under flowing conditions, the frequency of the reflected wave is different due to the Doppler effect. When the fluid moves faster, the frequency shift increases linearly. The transmitter processes signals from the transmitted wave and its reflections to determine the flow rate.

Using ultrasonic transducers, the flow meter can measure the average velocity along the path of an emitted beam of ultrasound, by averaging the difference in measured transit time between the pulses of ultrasound propagating into and against the direction of the flow or by measuring the frequency shift from the Doppler Effect. 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. The transmitter processes upstream and downstream times to determine the flow rate. Ultrasonic flow meters are affected by the acoustic properties of the fluid and can be impacted by temperature, density, viscosity and suspended particulates depending on the exact flow meter.

Ultrasonic flow meters are commonly applied to measure the velocity of liquids that allow ultrasonic waves to pass, such as water and certain chemicals. Transit time designs are also available to measure gas and vapor flow. Ultrasonic flow meters should not be used in fluids that do not pass ultrasonic energy, such as opaque fluids and many types of slurry which limit the penetration of ultrasonic waves into the fluid and can degrade accuracy of flow measurement.




**Ultrasonic flow meter**

### 3.3.1 Advantages of Ultrasonic water meter:

- Long term stability and accuracy over a wide range of conditions.
- High reliability and minimum maintenance requirement.
- Maintenance-free meter where no external power sources are available.
- Communication port permits transfer of data from remote stations to central system via GSM - GPRS Modem.
- Self-adjusting transducer continually adapts to changing pipe diameters due to scaling or corrosion
- Fast response to flow transits.
- Long Battery life - 5 years min.
- On-board self diagnostic function and fault indicator.

### 3.3.2 Disadvantages of Ultrasonic water meter:

- Cost is higher in comparison to other type of flow meter.
- Pipe wall needs to be fairly clean and free of rust and irregularities for getting better result.
- The prerequisites for accurate flow measurement are:
    - Pipe is full.
    - Fluid media conducts sonic energy.
    - Pipe wall is in good condition

### 3.3.3 Types of Ultrasonic flow meters:

There are two main types of Ultrasonic flow meters:

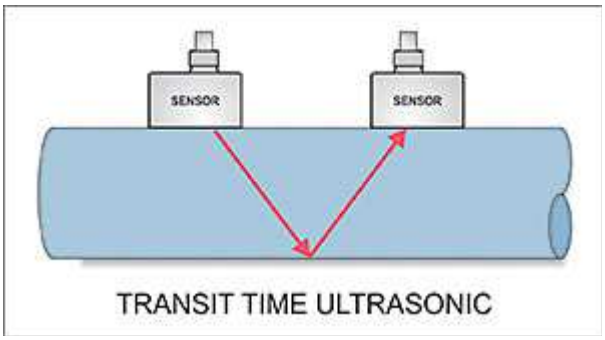
**A)** Transit time Transducer based
**B)** Doppler Transducer based

Both type Ultrasonic flow meters measure flow by using sensors clamped onto the outside of a pipe. Both Doppler and Transit Time flow meter technologies are called "ultrasonic" because they operate far above the frequencies or sound range that one can hear. The main component of each ultrasonic transducer is a piezo-electric crystal, which are in glass disks shapes about the size of a coin. These crystals are

polarized and expand or pulse a minute amount when electrical energy is applied to the surface electrodes. As it pulses the transducer emits an ultrasonic beam approximately 5° wide at an angle designed to efficiently pass through a pipe wall. The returning echo (pressure pulse) impacts a second passive crystal and creates electrical energy. This is the received signal in a Doppler or Transit Time transducer.

## A) Transit time transducer:

Transit Time transducers typically operate in the 1-2 MHz frequencies. Higher frequency designs are normally used in smaller pipes and lower frequencies for large pipes up to several meters in diameter. Transducer pairs/frequencies shall be selected according to the application. Transit Time flow meters *must* have a pair of transducers, each containing a piezo-electric crystal. One transducer transmits sound while the other acts as a receiver. Transit Time flow meters measure the time it takes for an ultrasonic signal transmitted from one sensor, to cross a pipe and be received by a second sensor. Upstream and downstream time measurements are compared. With no flow, the transit time would be equal in both directions. With flow, sound will travel faster in the direction of flow and slower against the flow. Because the ultrasonic signal must cross the pipe to a receiving transducer, the fluid must not contain a significant concentration of bubbles or solids. Otherwise the high frequency sound will be attenuated and too weak to traverse the pipe.

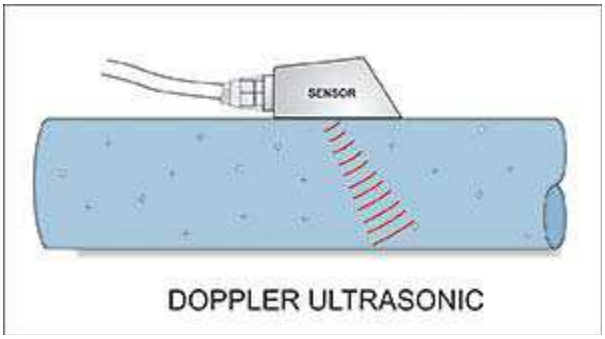



## B) Doppler Transducer based

Doppler transducers usually operate at 640 kHz to 1 MHz frequencies and work on a wide range of pipe diameters. Doppler flow meters use the principal that sound waves will be returned to a transmitter at an altered frequency if reflectors in the liquid are in motion. This frequency shift is in direct proportion to the velocity of the

liquid. It is precisely measured by the instrument to calculate the flow rate. So the liquid must contain gas or air bubbles for the Doppler measurement to work.

***Hence Doppler flow meters work best in dirty or aerated liquids like wastewater and slurries. Transit Time flow meters work with clean liquids like water, oils and chemicals.***




### 3.3.4 General features of Transit time transducer based Ultrasonic Flow Meter:

| Parameters | Specifications |
|---|---|
| Technical characteristics | Low power consumption, digital process technology with stable & permanent Piezo Seal sensor |
| Accuracy | Better than ±1% of reading |
| Repeatability | Better than 0.2% of span |
| Display | Total flow, flow rate, velocity, working time & date, signal intensity, quality & battery status |
| Output | RS 485,4-20 mA, Pulse for total flow (All outputs need external power supply 24 V DC) |
| Communication interface | GSM, GPRS (Can be battery powered) |
| Operation | Magnetic key & inside key pad available |
| Sampling period | 0.5 sec. |
| Environment temp. | 0 Up to $65^0$ C |
| Water temp. | 5 to $70^0$C |
| Power supply | i)3.6 V Lithium battery (Up to 5 years life)<br>ii) DC 9-28 Volts |
| Power Consumption | i) For recording data twice per second for pipe DN 300, |

| | |
|---|---|
| | the consumption is 0.18mW.<br>ii)Water meter should inter into energy saving mode when the pipe is empty/ consumption is only 30% as normal working. |
| Enclosure class | IP68(dustproof and submersible for a prolonged period of time |
| Pipe size | DN 20-600, DN600-1000 |
| Connection | With Flange |

## 4.0 Approximate Cost:

| S. No. | Description of Item | Manufacturer | Size (in mm) | Cost (in INR) |
|---|---|---|---|---|
| 1 | Mechanical Flow Meter | Northern region based manufacturer | 150mm | Rs.34,850/- |
| | | | 200mm | Rs. 40,650/- |
| | | | 300mm | Rs.1,55,500/- |
| | | | 400mm | Rs.2,84,500/- |
| | | | 500mm | Rs.3,49,000/- |
| 2 | Electromagnetic Flow meter | Northern region based | 150mm | Rs.84,500/- |
| | | | 200mm | Rs. 89,000/- |
| | | | 300mm | Rs.1,51,500/- |
| | | | 400mm | Rs.2,53,000/- |
| | | | 500mm | Rs.2,93,500/- |
| 3 | Ultrasonic Flow meter | Northern region based | 100mm-2500mm | Rs.5,65,000/- |

## 5.0 References:


1. ISO 4064: 2005 (Revised in 2014)
2. Literature available on internet.
3. Literature collected from following firms:
   i) M/s Iota Flow Systems Pvt. Limited,
      BE 200, Lane 6, Hari Nagar, New Delhi 110064.
   ii) Adept Fluidye Pvt. Ltd.
      Plot 4, S No.17/1-B,Kothrud Ind. Estate, Korthurd, Pune 411038.
   iii) Kaizen Imperial Scientific Leaders.
      B-1/6128,2nd Floor,Dev Nagar, Karol Bagh, New Delhi-110005 .
   iv) MTS Engineers Pvt. Ltd.
      B-408,Wall Street II, Orient Club, Nr.Gujarat Collage, Ellis bridge,
      Ahmedabad-380006.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