A BRIEF STUDY OF THE MOST COMMONLY USED FLOW METERS.

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Abstract

Throughout this paper we would like to introduce an overview of different flow meters available in the market for measuring flow in closed conduits, their applications, advantage and disadvantage and selection criteria. An explanation regarding the different basic operating principle of the most commonly used flow meter is provided to. The important of fluids flow measuring is also show. This paper will enhance a more exact appraisal of the performance of the different flow meter and provide the guide for the selection of the certain flow meter that the customer need.

Key works: *Flow Meter, flow, fluid flow, flow measuring*

1.0 Introduction

Measuring of fluids flow is essential in many industrial applications. In some applications, the ability to conduct accurate flow measurement is so important that it can make the difference between making a profit and taking a loss. In other cases, inaccurate flow measurements or failure to take measurements can cause serious results.

Flow measurement has evolved over the years in response to demands to measure new products, measure old products under new conditions of flow and for tightening the accuracy requirements as the value of the fluids goes up.

As a result of the prices of fluids going up, industrial set ups are therefore discovering the best flow meters that could be used to measure their fluid to approximately zero error.
Also selecting the right flow meter for a given application is something that should never be done haphazardly since there are important points to consider, for example, level of accuracy needed, reliability and durability, amount budgeted for the flow meter instrumentation etc. And once the correct flow meter is chosen, proper installation is also a key factor to consider. Improper installation can result in inaccurate measurements, premature wear and tear, and outright equipment failure, negating your flow meter investment.

This report therefore aims to give out an overview of different flow Meters available in the market for measuring flow in closed conduits, their applications and selection criteria in Water Flow Measurement and give an illustration of domestic water meter test as per IS 779:1994 / IS 6784:1996 and ISO 4064/3:1999.

2.0 Flow Meter

A flowmeter is a device that measures the rate of flow or quantity of a moving fluid in an open or closed conduit. It usually consists of both a primary and a secondary device. (Renganathan, S. 2005)

Flowmeter Primary device – is the device mounted internally or externally to the fluid conduit which produces a signal with a defined relationship to the fluid flow in accordance with known physical laws relating the interaction of the fluid to the presence of the primary device.

Flowmeter Secondary device – is the device that responds to the signal from the primary device and converts it to a display or to an output signal that can be translated relative to flow rate or quantity.

2.1 Why Meter

In order for one to understand the quantity of fluid flowing through a closed or open conduit, meter is very important. It helps in increasing efficiency, reduces waste, improves product or service quality and ensures the quantity of flow that we are manipulating. Metering also helps us understand the performance of the system in relation to design requirements.

2.2 Types of Flow Meters

There exist four types of flow meters for measuring flow in a closed piping system, namely:

- Differential Pressure meters
- Positive Displacement meters
- Velocity meters
- Mass flow meters

2.3 Uses of Flow Meters

Flow meters are used for:

- Quantification (i.e. estimation and planning)
- Management and Control of required demand)
- Calibrating other flow meters
- Custody transfer

3.0 Description of various flow meters, their advantages and disadvantages plus applications

As mentioned above, four types of flow meters are available for closed-piping systems, categorized as:

1. Differential Pressure meters
2. Positive Displacement meters

3. Velocity meters
4. Mass flow meters

3.1. Differential Pressure meters

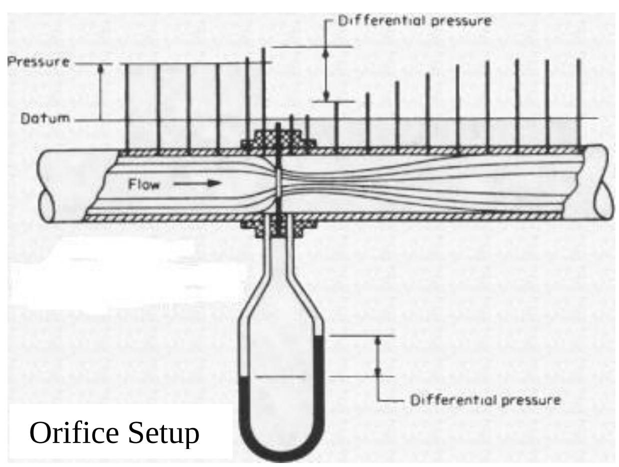
Differential pressure meters (also known as head meters) are, by far, the most common units in use today. Estimates are that over 50 percent of all liquid flow measurement applications use this type of unit. Some of the commonly used units include orifice plate, venturi tubes, flow nozzles, pitot tubes, and variable-area meters. Other meters which fall under this category are flow tubes, elbow tap meters and target meters. (Renganathan, S. 2005)

The basic operating principle of differential pressure flow meters is based on the principle that the pressure drop across the meter is proportional to the square of the flow rate. The flow rate is obtained by measuring the pressure differential and extracting the square root.

Differential pressure flow meters, like most flow meters, have a primary and secondary element. The primary element causes a change in kinetic energy, which creates the differential pressure in the pipe. The unit must be properly matched to the pipe size, flow conditions, and the liquid's properties. And, the measurement accuracy of the element must be good over a reasonable range. The secondary element measures the differential pressure and provides the output signal or read-out that can be converted to the actual flow value.

3.1.1 Orifice

Orifices are the most popular liquid flow meters in use today. An orifice is simply a flat piece of metal with a specific-sized hole bored in it. Most orifices are of the concentric type, but eccentric, conical (quadrant), and segmental designs are also available. Fig aside shows an orifice setup in the pipeline. In practice, the orifice plate is installed in the pipe between two flanges. Acting as the primary device, the orifice constricts the flow of liquid to produce a differential pressure across the plate. Pressure taps on either side of the plate are used to detect the difference.



Orifice Setup

In conical and quadrant orifice plates, the units were developed primarily to measure liquids with low Reynolds numbers. Essentially constant flow coefficients can be maintained at R values below 5000. Conical orifice plates have an upstream bevel, the depth and angle of which must be calculated and machined for each application.

The segmental wedge is a variation of the segmental orifice. It is a restriction orifice primarily designed to measure the flow of liquids containing solids. The unit has the ability to measure flows at low Reynolds numbers and still maintain the desired square-root relationship. Its design is simple, and there is only one critical dimension, the wedge gap. Pressure drop through the unit is only about half that of conventional orifices.

Integral wedge assemblies combine the wedge element and pressure taps into a one-piece pipe coupling bolted to a conventional pressure transmitter. No special piping or fittings are needed to install the device in a pipeline.

Metering accuracy of all orifice flow meters depends on the installation conditions, the orifice area ratio, and the physical properties of the liquid being measured.

Advantages

- low cost
- No moving parts and their cost does not increase significantly with pipe size.

Disadvantages

- High pressure loss
- Possibility of being plugged with slurry

Applications

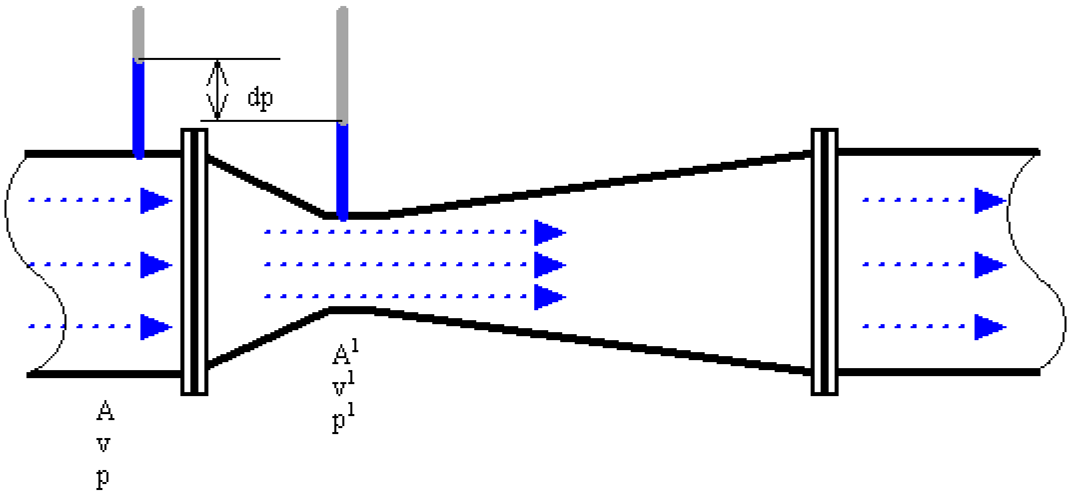
- Mostly used for Industrial application

3.1.2 Venturi tubes

Venturi meters can pass 25 – 50% more flow than an orifice meter. In a Venturi meter setup, a short, smaller diameter pipe is substituted into an existing flow line.

In the Venturi Tube the fluid flowrate is measured by reducing the cross sectional flow area in the flow path, generating a pressure difference. After the constricted area, the fluid passes through a pressure recovery exit section, where up to 80% of the differential pressure generated at the constricted area, is recovered.

By Bernoulli’s principle the smaller cross-sectional area results in faster flow and therefore lower pressure. The Venturi meter measures the pressure drop between this constricted section of pipe and the non-constricted section.



The discharge coefficient (Cd) for the Venturi meter is generally in the range from 0.94 to 0.99.

In the upstream cone of the Venturi meter, velocity is increased, pressure is decreased

• Pressure drop in the upstream cone is utilized to measure the rate of flow through the instrument

• Velocity is then decreased and pressure is largely recovered in the downstream cone

Due to simplicity and dependability, the Venturi tube flowmeter is often used in applications where higher turndown ratios or lower pressure drops than orifice plates can provide are necessary. With proper instrumentation and flow calibrating the venturi meter flowrate can be reduced to about 10% of its full scale range with proper accuracy. This proves a turndown ratio of around 10:1

Volumetric flow rate through a Venturi meter:

$$q = \frac{C_v S_b}{\sqrt{1-\beta^4}} \sqrt{\frac{2 g_c (P_a - P_b)}{\rho}}$$

where Cv - Venturi coefficient
Sb - Cross sectional area of downstream
β - Ratio of cs areas of upstream to that of downstream.
Pa-Pb - Pressure gradient across the Venturi meter
ρ - Density of fluid

Advantages

- Able to handle large flow volumes at low pressure drops
- Can be used with most liquids, including those having high solids content.

Disadvantages

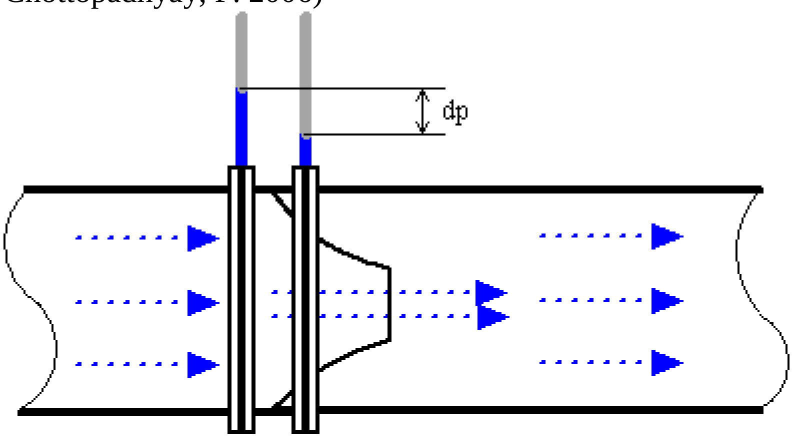
- Highly expensive
- Occupies considerable space (L/D ratio of approx. 50)
- Cannot be altered for measuring pressure beyond a maximum velocity.

Application

- Mostly used for liquids as water in industrial applications

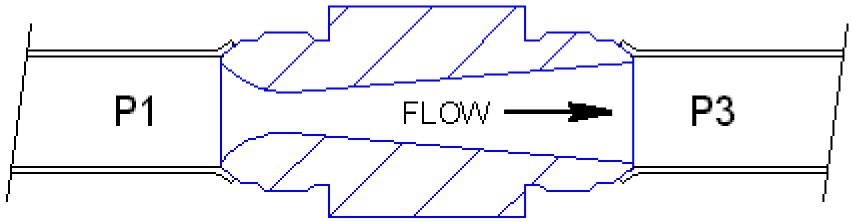
3.1.3 Flow Nozzle

Another type of differential pressure flowmeter is the flow nozzle. Flow nozzles are often used as measuring elements for air and gas flow in industrial applications. At high velocities, Flow Nozzles can handle approximately 60 percent greater liquid flow than orifice plates having the same pressure drop. For measurements where high temperatures and velocities are present, the flow nozzle may provide a better solution than an orifice plate. Its construction makes it substantially more rigid in adverse conditions and the flow coefficient data at high Reynolds numbers is better documented than for orifice plates. . The turndown rate of flow nozzles is similar to that of the orifice plate. Fig below shows the arrangement of a flow nozzle. (Chottopadhyay, P. 2006)



The Sonic Nozzle- Critical (Choked) Flow Nozzle

One type of flow nozzle is the sonic nozzle. The Sonic Nozzle is a converging-diverging flowmeter. It consists of a smooth rounded inlet section converging to a minimum throat area and diverging along a pressure recovery section or exit cone.



The Sonic Nozzle is operated by pressurizing the inlet (P1) or evacuating the exit (P3), to achieve a pressure ratio of 1.2 to 1 or greater, inlet to outlet. When a gas accelerates through a nozzle, the velocity increase and the pressure and gas density decrease. The maximum velocity is achieved at the throat, the minimum area, where it is equal to Mach 1 or sonic condition. At this point it's not possible to increase the flow by lowering the downstream pressure. The flow is choked. Pressure differences within a piping system travel at the speed of sound and generate flow. Downstream differences or disturbances in pressure, traveling at the speed of sound, cannot move upstream past the throat of the Nozzle because the throat velocity is higher and in the opposite direction.

Advantages

- Liquids with suspended solids/slurry can also be metered with flow nozzles.
- The flow nozzle is relatively simple and cheap, and available for many applications in many materials.

- Intermediate pressure loss
- Its construction makes it substantially more rigid in adverse conditions and flow coefficient data at high Reynolds numbers is better documented than for orifice plates.

Disadvantages

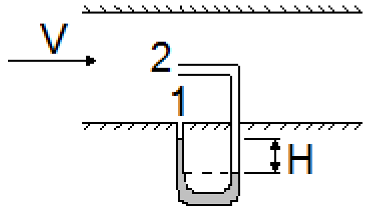
- Not recommended for highly viscous liquids or those containing large amounts of sticky solids

Applications

- For air and gas flow in industrial applications, Sonic Nozzles are used in many control systems to maintain fixed, accurate, repeatable gas flow rates unaffected by the downstream pressure.

3.1.4 Pitot tubes

Pitot tubes measure the local velocity due to the pressure difference between points 1 and 2 in the diagrams below. Unlike the other differential flow meters, the pitot tubes only detect fluid flow at one point rather than an overall calculation. The diagram shows a simple pitot tube configuration.



Pitot tube has two openings, one perpendicular to the flow and one parallel to the flow. The impact tube has its opening perpendicular to the fluid flow, allowing the fluid to enter the tube at point 2, and build up pressure until the pressure remains constant. This point is known as the stagnation point. The static tube, with openings parallel to the fluid flow gives the static pressure and causes a sealed fluid of known density to shift in the base of the tube. Pressure drop can be calculated using the height change along with the fluid densities and the equation below. (Renganathan, S. 2005)

$$\Delta P = \rho \cdot g \cdot H$$

This pressure drop can be related to the velocity after accounting for the losses throughout the piping in the system, given by C_p. This dimensionless coefficient is found through accurate calibration of the pitot tube. The equation below describes this relationship.

$$v = C_p \sqrt{\frac{2\,(p_1 - p_2)}{\rho}}$$

with v as the fluid velocity, C_p as the loss coefficient, p_1 as the pressure at point 1, p_2 as the pressure at point 2, and ρ as the flowing fluid's density.

Advantages

- Low cost, absence of moving parts, easy installation, and minimum pressure drop
- Cheaper than orifice plates and venture tubes.

Disadvantages

- Have low sensitivity and they require high fluid velocity
- The units are susceptible to plugging by foreign material in the liquid

Applications

- Pitot tubes are mainly used for gas lines, may also be employed where the flowing fluid is not enclosed in a pipe or duct e.g. For measuring the flow of river water, or it may be suspended from an aero plane for measuring air flow

3.1.5 Variable area meters

Variable-area meters, often called **rotameters**, consist essentially of a tapered tube and a float, **s**ee Fig. v below. Although classified as differential pressure units, they are, in reality, constant differential pressure devices. It has flanged-end fittings to provide an easy means for installing them in pipes. When there is no liquid flow, the float rests freely at the bottom of the tube. As liquid enters the bottom of the tube, the float begins to rise. The float is selected so as to have a density higher than that of the fluid and the position of the float varies directly with the flow rate. Its exact position is at the point where the differential pressure between the upper and lower surfaces balances the weight of the float.

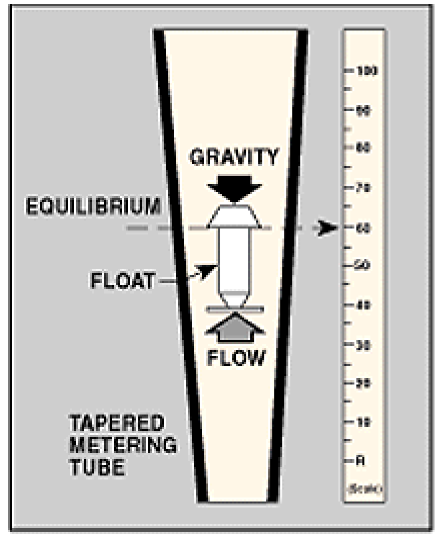


Fig v. Rotameter

Because the flow rate can be read directly on a scale mounted next to the tube, no secondary flow-reading devices are necessary.

However, if desired, automatic sensing devices can be used to sense the float's level and transmit a flow signal. Rotameter tubes are manufactured from glass, metal, or plastic. Tube diameters vary from 1/4 to greater than 6 in. (Renganathan, S. 2005)

Advantages for variable area flow meters

- Low cost and simple to install
- Virtually maintenance free and easy to use as the flow rate can be read directly on a scale mounted next to the tube
- Can handle wide range of aggressive fluids

Disadvantages for variable area flow meters

- Lower accuracy compared to many other flow meter technologies
- Reading can be affected by pulsation
- Sensitive to fluid changes such as viscosity, density and temperature
- Bigger size meters are very expensive

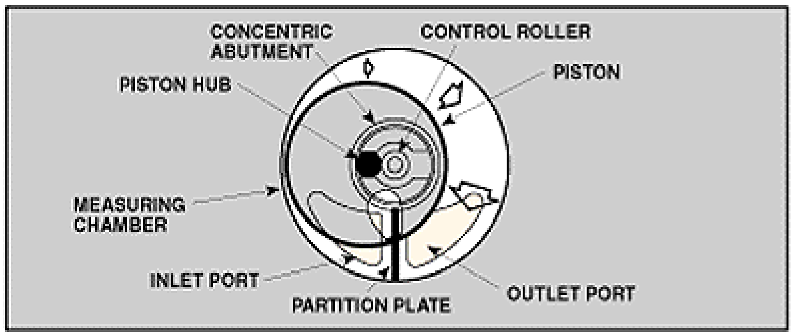
Application

- Measuring Liquid flow or gas flow where high accuracy is not required
- Measuring water and gas flow in plants or labs
- Monitoring chemical lines
- Monitoring filtration loading

- Monitoring flow in material-blending applications (i.e. lines that use a valve meter)
- Monitor makeup water for food & beverage plants

3.2. Positive Displacement meters

Positive Displacement meters are of four types namely Reciprocating Piston, Oval gear, Nutating Disk and Rotary Vane. The commonly used one out of these is the Reciprocating Piston. Operation of these units consists of separating liquids into accurately measured increments and moving them on. Each segment is counted by a connecting register.



Because every increment represents a discrete volume, positive-displacement units are popular for automatic batching and accounting applications.

Advantages

- A Positive displacement flow meter does not require a straight pipe run before the flow meters inlet
- High accuracy
- Flow measurement is independent of viscosity
- Pulsed output allow connection to a wide range of displays and controllers including options for flow rate, totalized flow, batch control and connection options to a PC or PLC for control

Disadvantages

- Fluid with suspended particulates can lead to line blockages
- Can be damaged by sudden changes in flow
- Meter can be more bulky than other flow technologies

Application

- Metering of methanol or fuel particularly when used for fiscal measurements and custody transfer
- Measurement of high viscosity fluids in the manufacturing process
- Measurement of viscous fluids in the lab

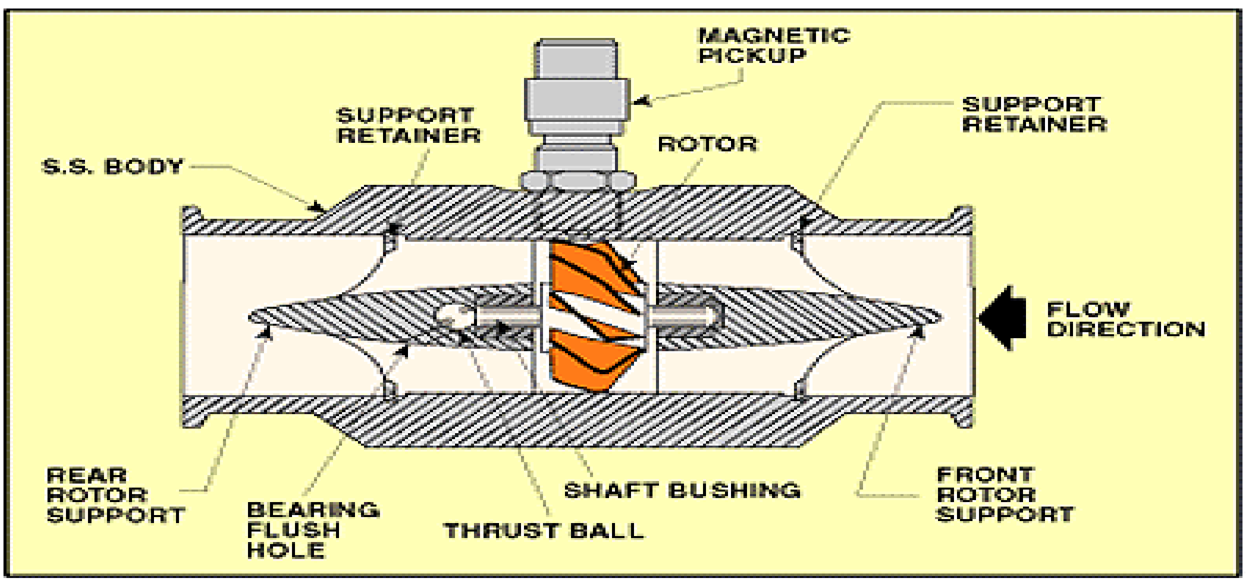
- Verification of proper bearing-lubricant delivery in hydraulic applications
- Monitoring batching volumes in industrial processes

3.3. Velocity water meters

Velocity meters operate linearly with respect to the volume flow rate. Because there is no square-root relationship (as with differential pressure devices), their range ability is greater. Velocity meters have minimum sensitivity to viscosity changes when used at Reynolds numbers above 10,000. Most velocity-type meter housings are equipped with flanges or fittings to permit them to be connected directly into pipelines. Various types of velocity meters available and commonly used are Turbine meters, Vortex Shedding, Electromagnetic, and Ultrasonic Transit-Time. (Chottopadhyay, P. 2006)

3.3.1 Turbine meters

Turbine meters have found widespread use for accurate liquid measurement applications. The unit consists of a multiple-bladed rotor mounted with a pipe. The rotor spins as the liquid passes through the blades. In rotation, the rotating blades generate a frequency signal proportional to the liquid flow rate which is sensed by a magnetic pickup and transferred to the output indicator. Electrical pulses can be counted and totalized, Fig. below



The number of electrical pulses counted for a given period of time is directly proportional to flow rate. A tachometer can be added to measure the turbine's rotational speed and to determine the liquid flow rate. Turbine meters, when properly specified and installed, have good accuracy, particularly with low-viscosity liquids. A major concern with turbine meters is bearing wear.

Advantages

- High accuracy and good repeatability
- Fast response time – typically a few milliseconds

- Wide flow range options for both liquids and gases
- Good flexibility with associated digital readout devices including flow control options for both PC and PLC's

Disadvantages

- Very costly and not easily maintained in case of breakdown
- Accuracy of the meter is affected by temperature and viscosity change
- Require upstream straightened and filter for best results

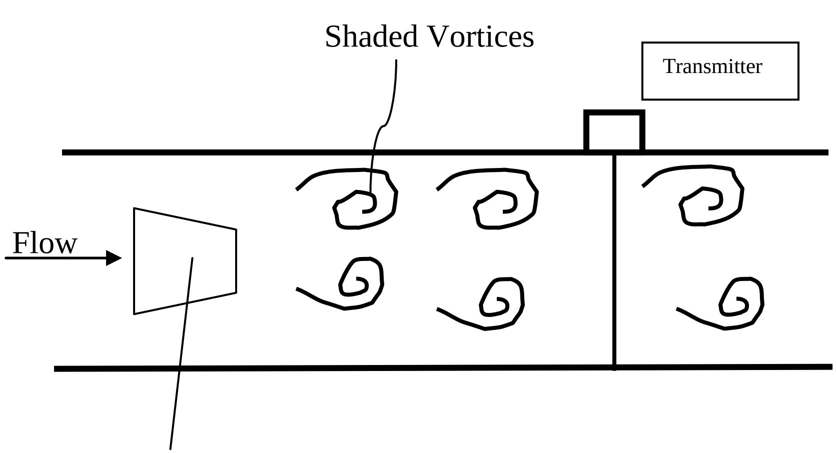
- May over-read in pulsating flows
- Turbine flow meters for liquid can require regular re-calibration due to bearing wear
- At low flow rate the meter loses linearity hence accuracy decreases

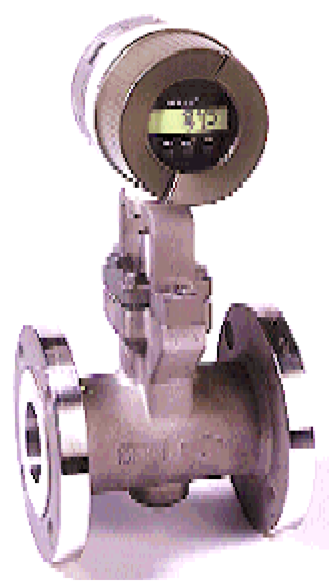
Application

- Most suitable for natural gas and fluid flows with no suspended particles
- Pilot plants
- Research and development facilities
- Inventory control metering applications
- Test/calibration stands

3.3.2 Vortex flow meters

Vortex meters make use of a natural phenomenon that occurs when a liquid flows around a bluff object. A blunt, non streamline body is placed in the stream of the flow through a pipe. When the flow stream hits the body, a series of alternating vortices are produced, which causes the fluid to swirl as it flows downstream. The number of vortices formed is directly proportion to the flow velocity and hence the flow rate. The vortices are detected downstream from the blunt body using and ultrasonic beam that is transmitted perpendicular to the direction of flow. As the vortices cross the beam, they alter the carrier wave as the signal is processed electronically, using a frequency to voltage circuit. The diagram below shows the basic principle of the vortex shedding flow meter:





Vortex shedding flow meters are best used in turbulent flow with a Reynolds number greater than 10,000.

Advantages

- Low medium initial setup cost
- No much maintenance needed when used in clean flow conditions
- Insensitivity from temperature, pressure and viscosity

Disadvantages

- Can create low to medium pressure drop due to obstruction on the medium

3.3.3 Electromagnetic meters Operating principle of these meters is based on Faraday's Law, which states that the voltage induced across any conductor as it moves at right angles through a magnetic field is proportional to the velocity of that conductor; the magnetic flow meter provides an obstractionless flow meter that essentially averages velocity over the pipe area. Fluid to be measured must have a conductivity of at least 2µS/cm to be measurable. A voltage is generated by the flow meter that is mutually perpendicular to flow direction and magnetic field is detected by two flush mounted electrodes on a diameter of a non conducting pipe wall. The low level millivolt signal is proportional to the average pipeline velocity, and , for this reason, magnetic flow meter are ideally suited for all conductive fluids being Corrosive, Strong acids and bases, Liquid metal, Viscous materials, Pulp & paper industry, Dyes, Sludge, Slurries, Alum, Influent/Effluent from Waste Treatment Plants, Chemical Wash, Liquids with Suspended Solids that operate in both the laminar and turbulent flow regimes.

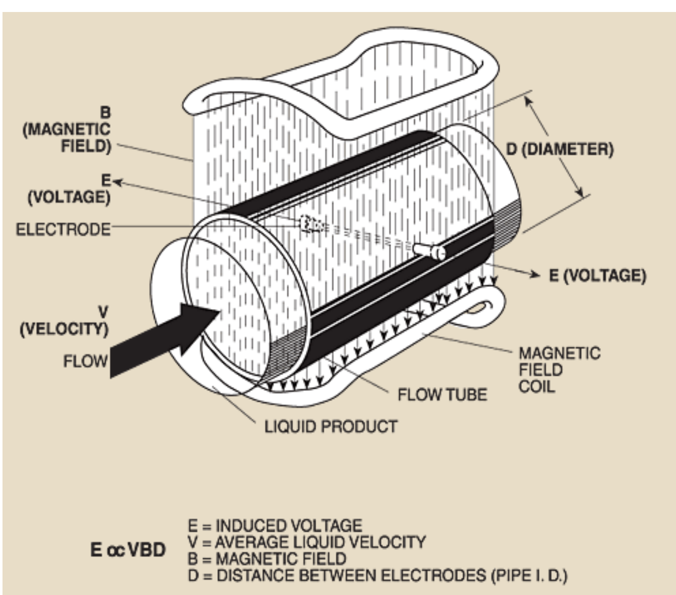


Fig 3.3 Magnetic Flow meter

Advantages

- Insensitivity to viscosity, specific gravity, temperature and pressure (within certain limitations)
- Works at all flow conditions. Laminar, turbulent, and transitional flows
- Can respond well to fast changing flows (for high-frequency DC pulse and AC excitation designs only)
- High accuracy up to (0.5 to 0.3%)
- Can handle slurries and heavy particulates
- No flow interference, almost no pressure drop

Disadvantages

- Fluid must be conductive (typically > 2µS/cm)
- Mainly used for liquids as it does not work well for gases
- Very expensive

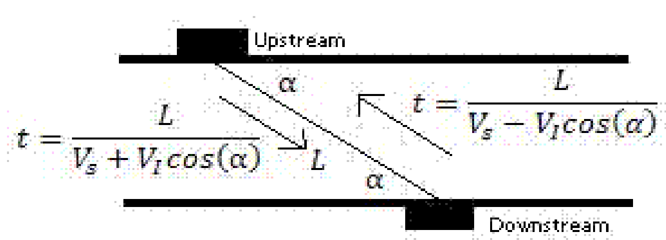
Applications

- Water monitoring in industrial plants
- Monitoring and control of a variety of industrial effluents such as Mining slurries, Brine, Sludge, Detergents, Corrosive acids etc

3.3.4 Ultrasonic Flowmeter (Transit time)

In these meters a high frequency (approximately 1MHZ) pressure wave is beamed at an acute angle across the pipe. The time required for the wave to reach the opposite wall depends on whether it is moving with or against the flow and on the speed of sound through the liquid. The flow rate information is obtained from the measured time.

Transit time meters have two opposing transducers outside of the pipe to measure the time of a signal sent from a transducer upstream to a transducer downstream and vice versa.



V : mean fluid velocity along the chord AB

L: Lenth of the chord AB

d: projection of L onto pipe axis

t: A to B and B to A transit time respectively

The mean velocity of the fluid can be determined from the equation below, and using the continuity equation, discharge can be determined also.

$$\overline{V} = \frac{L^2}{2d}\left(\frac{\Delta f}{t_{AB} - t_{BA}}\right)$$

These meter are suitable for wastewater, service water, lubricating oils, highly corrosive liquids, for all liquids bearing 25PPM of 30 microns or larger suspended solids or bubbles.

Advantages

- Process contamination free measurement of flow
- No leak potential
- Insensitive to liquid temperature, viscosity, density or pressure variations
- Allows for easy installation without disturbing existing pipe work
- Suitable for aggressive chemicals as no contact with the media

Disadvantages

- Higher initial setup costs than other flow technologies
- Pipe material must be compatible with ultrasonic sensor

Applications

- Measure clean water flow rate in treatment plants
- Pure and ultra-pure fluids in semiconductor, pharmaceutical, and the food & beverage industries
- Light to medium crude oils in the petroleum refining industry
- Acids and liquefied gases in the chemical industry

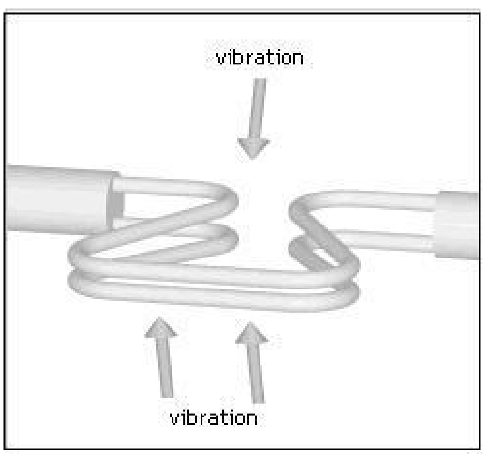
3.4. Mass Flow Meter

A Coriolis flow meter harnesses the natural phenomenon wherein an object will begin to "drift" as it travels from or toward the center of a rotation occurring in the surrounding environment. A merry-go-round serves as a simple analogy; a person travelling from the outer edge of the circle to its center will find himself deviating from his straight-line path in the direction of the ride's rotation.

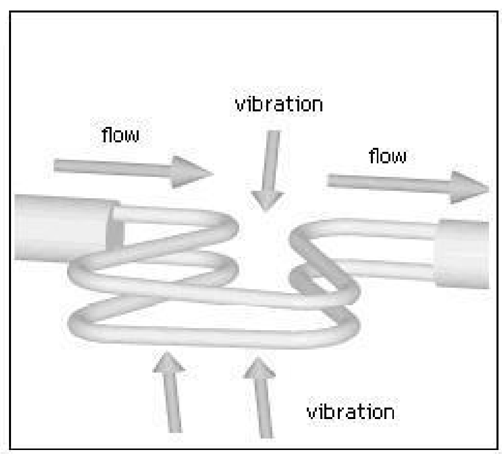
Coriolis flow meters generate this effect by diverting the fluid flow through a pair of parallel U-tubes undergoing vibration perpendicular to the flow. This vibration simulates a rotation of the pipe, and the resulting Coriolis "drift" in the fluid will cause the U-tubes to twist and deviate from their parallel alignment. This Coriolis force producing this deviation is ultimately proportional to the mass flow rate through the U-tubes. (Chottopadhyay, P. 2006)

$$MassFlow = \frac{F_c}{2wx}$$

where Fc is the Coriolis force observed, *w* is the angular velocity resulting from rotation, and *x* is the length of tubing in the flow meter.



Coriolis flow meter undergoing no flow.



Coriolis flow meter exhibiting deflection as a result of mass flow

Because the Coriolis flow meter measures the mass flow rate of the fluid, the reading will not be affected by fluctuations in the fluid density. Furthermore, the absence of direct obstructions to flow makes the Coriolis flow meter a suitable choice for measuring the flow of corrosive fluids.

Advantages

- Can be used in a wide range of liquid flow conditions
- Capable of measuring hot (e.g. molten sulphur) and cold (e.g cryogenic helium, liquid nitrogen) fluid flow.
- Coriolis flowmeters measures the mass flow rate directly which eliminates the need to compensate for changing temperature, viscosity, and pressure conditions.

- Higher accuracy than most flow meters

- Has low pressure drop
- Suitable for bi-directional flow

Disadvantages

- High initial setup cost
- Limited line size availability
- Large in over-all size compared to other meters
- In case of clogging, it is difficult to clean
- Very costly
- Sensitive to vibrations
- Diminished accuracy in the presence of low-flow gases.

Application

- Custody Transfer
- Metering natural gas consumption
- Conducting a primary check on a secondary flow meters

4.0 Flow meters commonly used in water flow measurement in Domestic Water Supply.

Flow meters commonly used in water flow measurement in water supply systems are:

Single jet meter, Multi jet water meters for domestic customer connection and Electromagnetic meters mainly as bulk meters.

Single jet and multi jet flow meter usually use mechanical procedure in which water through a pipeline rotates a mechanical wheel. This mechanical wheel rotates the gears set which give out the reading in m^3/h.

For Electromagnetic meters, working procedure is as stated in Para. 3.3.3 Above.

5.0 Testing of Domestic Water meter

5.1 Introduction

Domestic Water meters are normally tested for accuracy measurement, pressure tightness, pressure loss, temperature suitability and wear resistance.

There are two methods in which a water meter can be tested:

1. Primary Method
   In this method one can use either weighing method or volumetric method
2. Secondary method
   In this method one can use reference flow meters e.g. electromagnetic flow meter, turbine flow meter etc

Out of the two methods mention above, Primary method is the most accurate especially weighing method.

Before starting meter testing, there are preliminary requirements which one should adhere to for example one has to specify whether the test is for the determination of measurement error, pressure loss, wear resistance etc

Also water meter to be tested has to be inspected to ensure that it conforms to the technical characteristics described in ISO 4064 -1, the tests has to be carried out as per the procedure described below which is based on IS 779:1994 / IS 6784:1996 and ISO 4064/3:1999. The regulations and permitted tolerances in the measurement of physical quantities associated with the water meter test methods and equipments as per ISO 4064/3:1999 has to be fully followed during testing.

Tests include the following carried out in the order indicated:

a) Pressure Tests
b) Determination of the error curves as a function on flow rate
c) Pressure loss tests
d) Acceleration wear tests

5.2 Test Procedure

Initially, water meters were checked for dimensional verification, verification scale interval and marking.

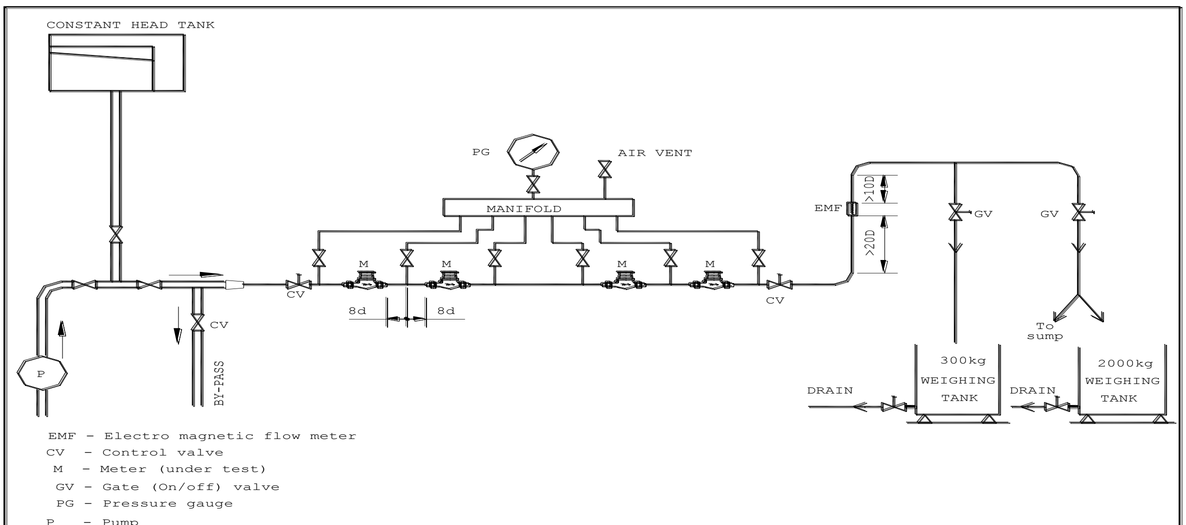
Then the meters were subjected to pressure tightness test. For this, the meters were subjected to continuous water pressure of 1.6MPa for 15 minutes and afterwards 2.0MPa for 1 minute. Then the meters were subjected to flow tests. Flow test consists of measurement error determination and determination of pressure loss. Measurement error was determined at different flow rates like maximum (Qmax), nominal (Qn), transitional (Qt) and minimum (Qmin) flow rates. For 15mm Class B domestic water meters, these flow rates were 3000 l/hr, 1500 l/hr, 120 l/hr and 30 l/hr respectively. Accuracy tests were conducted in three additional points at 300 l/hr, 750 l/hr and 1125 l/hr. The permissible metering accuracy is ±5% from Qmin (inclusive) to Qt (exclusive) and ±2% from Qt (inclusive) to Qmax (inclusive). Head losses across the meters were measured at 1500 l/hr and 3000 l/hr. The permissible values for head loss for Qmax and Qn are 0.1 MPa and 0.025 MPa respectively.

After undergoing the pressure and flow tests, the meter(s) are subjected to temperature suitability test. This test consists of immersing the meters continuously in a water bath maintained at 45±1 deg. °C for 10 hours and subjecting meter again for pressure and flow tests as described above.

The meter(s) are then subjected to accelerated endurance test (life test). Life test consists of discontinuous flow of 100,000 cycles of interruptions. Each interruption consists of flow at 1500 l/hr for 15 sec. and a pause time of next 15 sec. The flow rate is ensured using an electro-magnetic flow meter. After this discontinuous flow test, the same meter(s) are subjected to continuous flow test at 3000 l/hr. for 100 hours. After the life test, the meter(s) are subjected to pressure tightness and flow tests.

5.3 Test set up

A schematic diagram of the test rig used for flow tests such as metering accuracy and loss of pressure is shown in fig below. Whether is single of more than one meter, the meters are accommodated in the test rig with suitable upstream and downstream straight lengths. Pre-calibrated electromagnetic flow meter was used as reference flow meter to adjust the flow rates. Constant head tank was used to supply water to the test rig. Metering accuracy of the test meters was checked against a 300-kg weighing system with resolution of 1gm. The desired flow rates were achieved by adjusting the downstream control valve. Resistance Temperature Detector (RTD) was used for measuring the temperature of water. A high precision pressure gauge was used to measure the loss of pressure. (Liptak. 2010)



TEST SET-UP FOR ACCURACY TEST

A schematic diagram of the test rig used for accelerated endurance test is shown in below

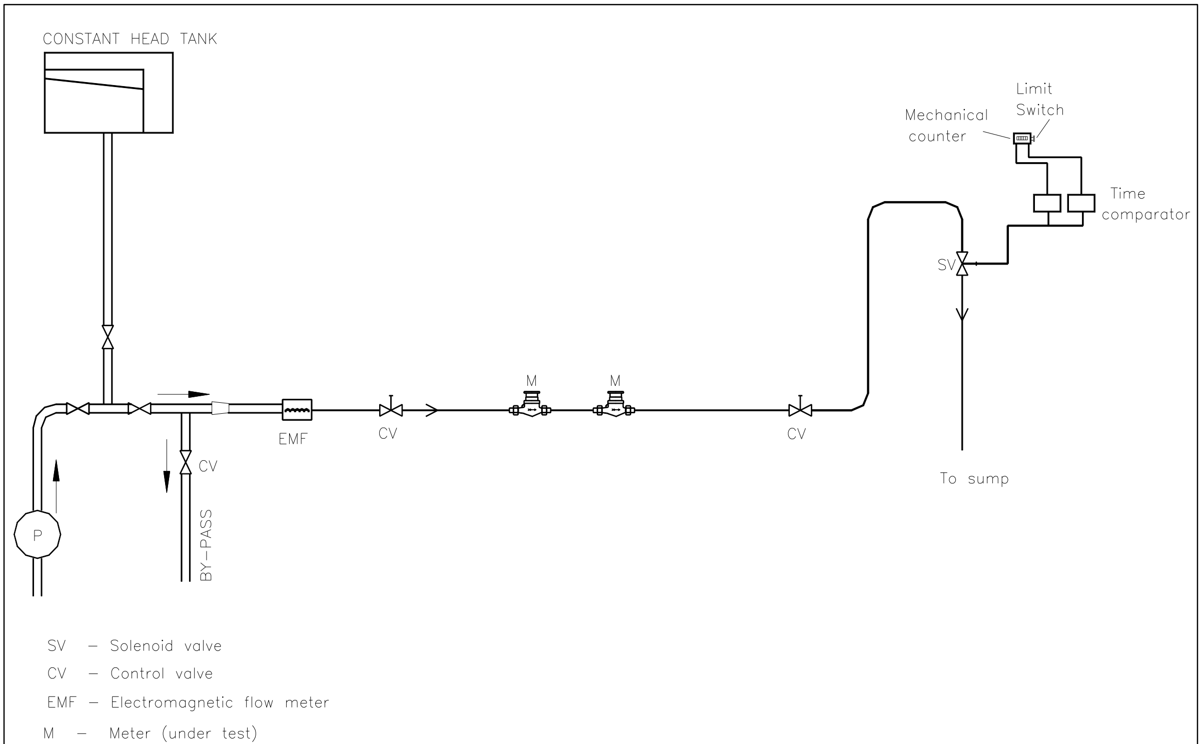


Fig.2 Test set-up for life test

Water meters were accommodated in series as shown in the figure. A solenoid valve fitted at the downstream with a dedicated electronic circuit was used to facilitate discontinuous flow at fixed time interval. An electro-mechanical counter was used to count the number of interruptions. Constant head tank was used to provide supply of water to the test rig. Upstream control valve was used to control the flow rate.

5.4 Certification

Is very important when you testing a meter to obtain the certification of the test from the laboratory in which this test was made. When this laboratory is accredited by the International Standard Accreditation System, it can provides you a feedback to laboratories as to whether the work in accordance with international criteria for technical competence. The accredited laboratory provides reliable testing and calibration services to meet the customer's need.

Calibration/test results are reported in a Calibration/test Certificate and it should include all the information requested by the client and necessary for the interpretation of the calibration/test results and all information required by the method used. As per ISO/ITEC – 17025:1999 a calibration certificates should include at least the following information:

1. A title: say "Calibration Certificate".
2. Name and address of the Laboratory.
3. A unique Serial No./Identification Number for each calibration certificate.
4. Name and address of the client.
5. Specifications/identifications of test equipment.
6. Calibration procedure or reference number for procedure.
7. Date(s) of receipt of calibration item and date(s) of performance of calibration.
8. Calibration results.

9. The name(s), function(s) and signature(s) or equivalent identification of person(s) authorizing the calibration certificate.
10. Where relevant, statements (1) “the results presented in this certificate relate only to the items mentioned and calibrated” (2) the calibration certificate shall not be reproduced except in full, without written approval of the laboratory.
11. The conditions (Environmental) under which the calibrations were made that have an influence on the measurement results.
12. Evidence that the measurements are traceable.
13. Uncertainty statement.

6.0 Conclusion

Each type of flowmeter has its own specific applications and installation constraints. There is no "one size fits all" flowmeter. The way to select the right flowmeter is to use the application as your guide, not the technology. Many of these technologies will all work well on many applications. If you start with the application, you can select the technology you wish to use based on accuracy, cost, durability and reliability, rather than trying to make the technology you chose fit the application you have.

References

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