Differential Meters other than Orifice

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Introduction

Cone Meters differ from other differential pressure type meters, such as Orifice Meters and Venturi Meters, basically by design only. They are all required to meet API Chapter 22.2 test criteria developed and published in 2005 and still being updated today. The Cone Meter is designed to measure liquid or gas. Cone Meters are proprietary in design and have limited third party testing due to patented designs and length of use in the Industry. The Orifice Meter is the oldest meter of the three that we will discuss and has the most third party flow lab test data available. The Venturi Meter history has mostly been utilized for liquids and steam. The Venturi is also known to preform very well in harsh flows, such as sewage, waste water and pulp due to its free flowing design. In recent years Venturis are more commonly being used for LNG & CNG due to the ability to construct them from a wide variety of materials.

History

Differential producing meters have been in service for over 100 years. The Orifice plate has been the most accepted in the Oil & Gas Industry since its inception for custody transfer. The Venturi introduced in the 1800's has been accepted in harsh non custody transfer such as Municipal water, sewage, or pulp. The Cone meter was introduced over 30 years ago and is still considered in its infancy due to Patent designs and not readily accepted as an alternative to Orifice Meters.

How are cone meters different from other types of differential meters?

First let's discuss the most predominant and widely accepted differential meter, The Orifice Meter.

The Orifice Meter is the most predominantly utilized device for measurement of natural gas. It's dominant presence in the natural gas industry stems from many decades of acceptance as the primary means for accurate hydrocarbon measurement. The Orifice Meter has the most third party flow lab test data of any differential metering device, as well as thousands of papers written about it. The newest revisions are in the 2000 AGA Part 3, Chapter 2 publication. Simple by design, it consists of a straight upstream and downstream pipe with an Orifice plate centrally located bore to create a differential. This pressure difference will incorporate the Bernoulli equation to determine a flow rate.

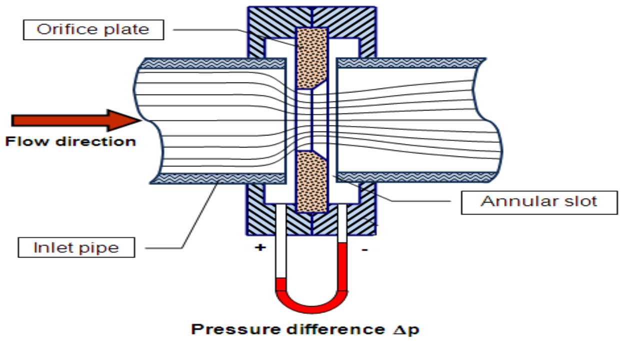
The Bernoulli Equation

$$\frac{P_1}{\rho} + \frac{1}{2}V_1^2 + gZ_1 = \frac{P_2}{\rho} + \frac{1}{2}V_2^2 + gZ_2$$

Below are some requirements of the Orifice Meter:

- Uses Bernoulli Equation
- Requires flow conditioner for shortest tube design 13D Upstream Pipe
- Requires Straightening Vane for 17D-29D Upstream Pipe
- Requires 145D of Upstream Pipe with No Flow Conditioner
- Downstream tube requires 4.2D-5D
- 3:1 Turndown Ratio on Orifice
- Coefficient of discharge .65
- Has a high PPL around 70% (Permanent Pressure Loss)
- Poor efficiency (High PPL = higher energy cost)
- By design the Orifice Plate is susceptible to sudden impacts that cause damage as the flow must pass through the center of the pipe and continually wear at sharp edge of bore.
- By design congregation of liquids or solids will form in front and behind the plate causing measurement errors.

Orifice Meter Illustration:

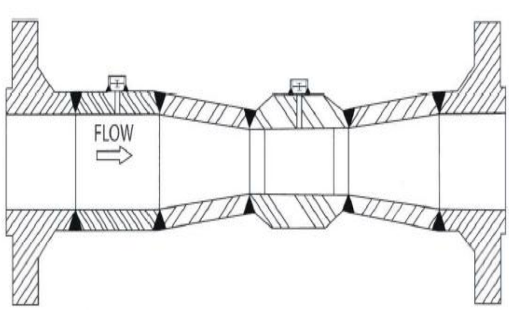


Next we will discuss the Principle of the Venturi Meter.

Like the Orifice Meter, **the Venturi Meter** has been around over a Century. Inside the Venturi Meter the fluid/gas is accelerated through a converging cone with an angle of 15-21º. The pressure difference between the upstream side of the cone and the throat is measured. This differential provides a signal for the rate of flow. This meter consists of two conical pipes connected to a throat to produce differential. This pressure difference can incorporate the Bernoulli equation to determine a flow rate. The differential producing Venturi Meter has a long history of uses in many applications. Due to its simplicity and dependability, the Venturi is among the most common flow meters. With no moving parts or abrupt flow restrictions, the Venturi can measure fluid flow rates with a minimal total pressure loss.

The principle behind the operation of the Venturi flow meter is the Bernoulli Effect. The Venturi Meter measures a fluid's flow rate by reducing the cross sectional flow area in the flow path and generating a pressure difference. After the pressure difference is generated, the fluid is passed through a pressure recovery exit section where up to 80% of the differential pressure generated at the throat is recovered. This makes the Venturi Meter much more efficient than the Orifice Meter.

Venturi Meter Illustration:



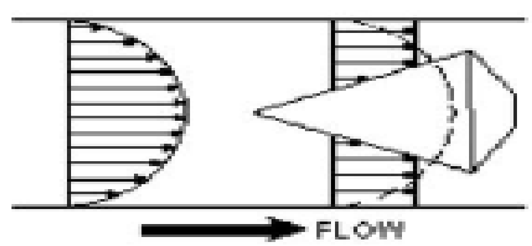
Below are some requirements of the Venturi Meter:

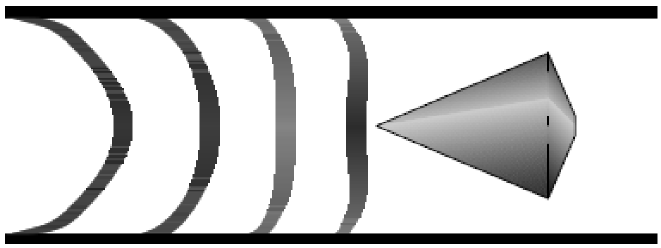
- Uses Bernoulli Equation
- Venturi requires 5D Upstream and 2D Downstream Pipe
- 10:1 Turndown Ratio
- Coefficient of discharge .95
- Has a Low PPL (Permanent Pressure Loss) of around 20%. Higher efficiency than an Orifice Meter
- By design the Venturi Meter is not as susceptible to impact as any debris would be a deflected or have a glancing blow
- No place for congregation of liquids or solids, self-cleaning by free-flow design

Next is the Cone Meter.

Cone Meter Illustration:

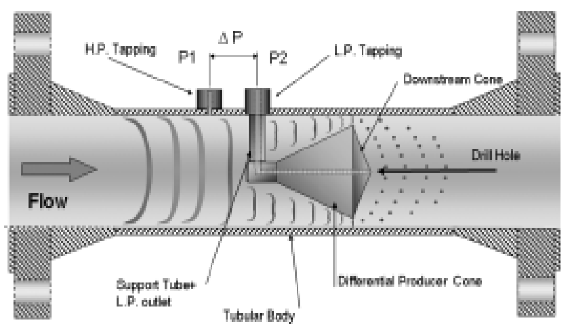
The centrally located cone inside the meter body reshapes the profile of the flow as it enters the meter body. The cone can have many different diameters which makes most “Cone Meters” a fixed Beta Ratio. The principle of the meter is similar to that of the Orifice Meter and the Venturi Meter, using a Beta Ratio. As the flow comes into contact with the cone, it creates a low pressure region just downstream of the cone. See illustrations below:





This pressure difference can incorporate the Bernoulli equation to determine a flow rate. This unique design and how it changes the profile of the gas as it enters the meter without a flow conditioner assures accurate and repeatable measurement even with harsh upstream conditions. Little or no upstream piping required.

Flanged Cone Meter Illustration:

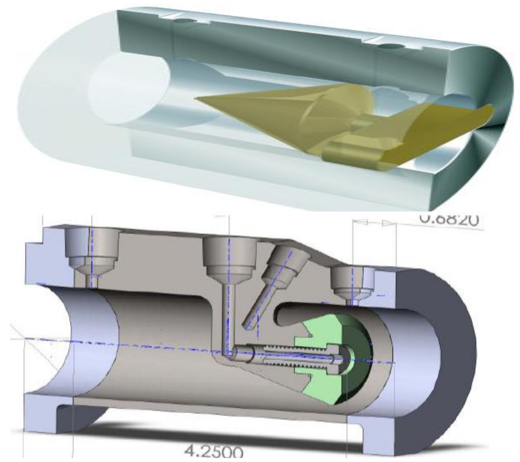


<u>Cone meter advantages over other differential type meters:</u>

Advantages:

- Doesn't require the upstream straight pipe of an Orifice Meter
- Can be located closer to upstream disturbances
- Lower permanent pressure loss, more efficiency
- Self cleaning design
- Design causes static mixing downstream for liquids
- Central location of cone conditions a disrupted flow
- Turndown ratio is greater than orifice plate (10:1 or better)
- Operation & Maintenance cost are lower
- Smaller foot print
- Weights less than Orifice Meter
- Easier to install due to reduced size
- Doesn't require a flow conditioner
- Cone design directs flow without abrupt surface impact
- No rubber seal rings to replace

Some cone meters have inter changeable beta-ratios, See below Illustration:



- High accuracy
- No areas of stagnation
- Typically the meter is smaller than pipeline
- Lower signal noise
- Predictable flow profile

Disadvantages:

- New Technology not easily accepted in industry
- Most designs have fixed Beta Ratios
- Low flow / low Reynolds Number Limitation
- Orifice Meter has much wider acceptance in the gas industry.

<u>Conclusion:</u>

Cone Meters will struggle to be accepted because it is a new design even at 30 plus years of age. Recent advances in Cone Meter construction allowing Beta Ratios to be changed allowing the Cone Meter a broader range ability. Most companies still believe Meters that worked 30 years ago will still be what we use today. Due to the design and construction of the Cone Meter using CNC equipment, the geometry of the Meter ID and the eccentricity of the cone produces a much more accurate and repeatable differential meter. It will continue to take time and resources with future testing in order for most companies to accept this new metering technology for liquid and gas measurement.

Glossary:

Efficiency

Efficiency is the ratio of output to input. No machine gives out as much energy or power as is put into it in the form it is intended for. There are some losses even in the most perfectly constructed machines. Efficiency is usually expressed as a percentage.

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