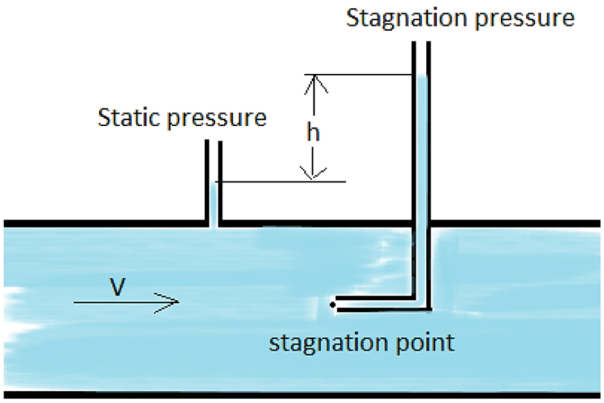
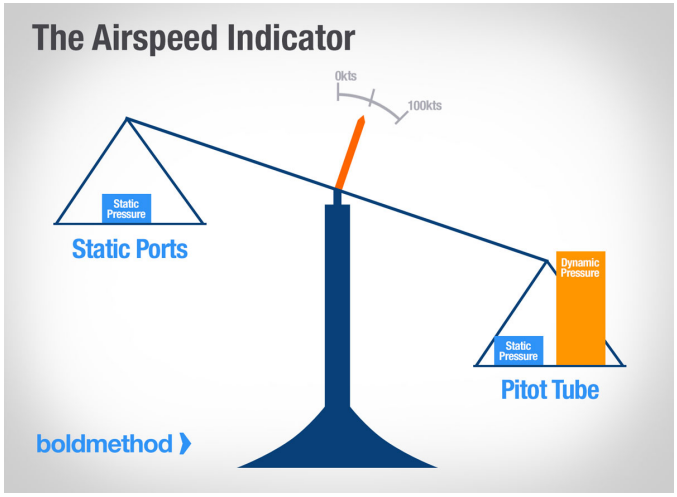
Pitot Tubes

$$V_{flow} = \sqrt{2 \cdot \frac{p_{stagnation} - p_{static}}{\rho_{fluid}}}$$



Pitot Tubes



Pitot Tubes

Pitot Tubes

AIRCRAFT

Pitot Tubes

SEACRAFT

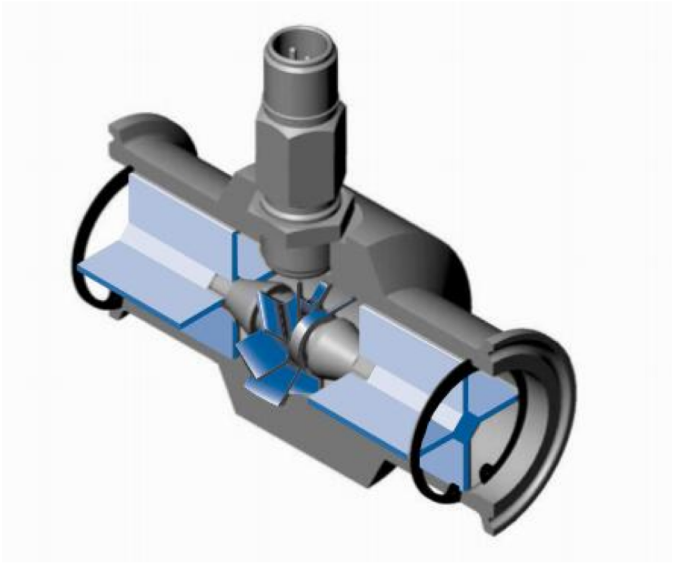
Pitot Tubes

LANDCRAFT

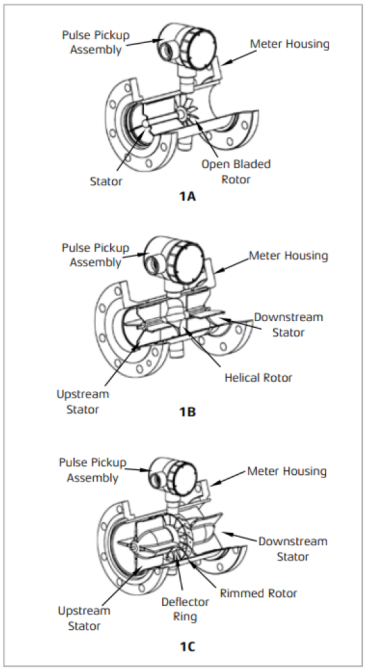
Pitot Tube Comparison

- Pros
  - ❑ Cheap
  - ❑ No maintenance
  - ❑ No moving parts
  - ❑ Wide T range
  - ❑ Wide P range
- Cons
  - ❑ Low accuracy
  - ❑ Prone to blockage
  - ❑ Requires high speeds

TURBINE FLOW METERS



Types



Open Bladed Rotor (1A)

Helical Rotor (1B)

Rimmed Rotor (1C)

Flow Straighteners

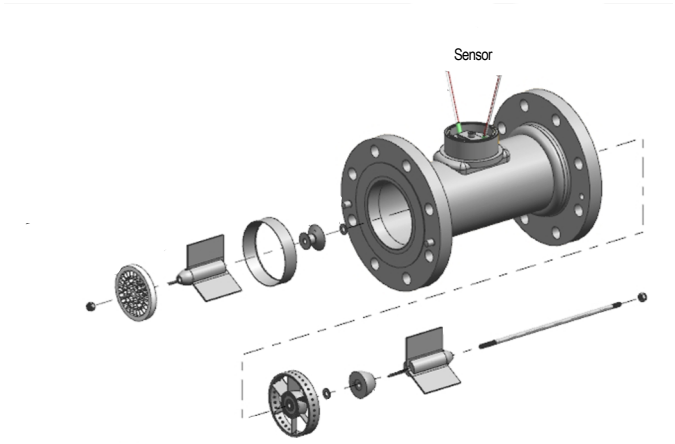
Spins Turbine

Sensor Pickup

Flow Rate

How They Work

Parts



Trade-Offs

PROS

- High Accuracy
- Repeatable
- Workable range
- High pressures
- Low flow rates
- Can heat the body to prevent freezing

CONS

- Only Low Viscosity
- Known Viscosity
- Lead/Exit Pipe
- Clean Fluids
- Calibration/Specs
- Pressure Drop/Losses

FLUIDS LAB!

WATER/GASSES/FUELS

FOOD/BEVERAGE INDUSTRY

INDUSTRIAL PLANTS

Applications

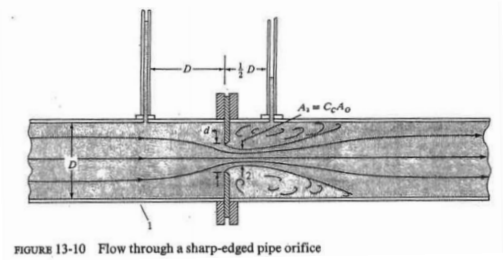
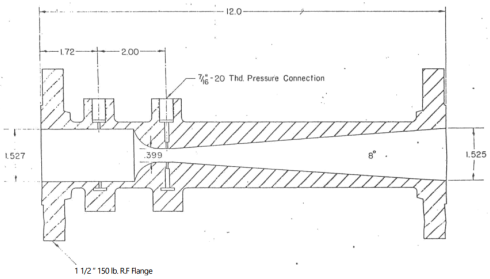


FIGURE 13-10 Flow through a sharp-edged pipe orifice



Orifice and Venturi Flowmeters

The Venturi Effect

- Giovanni Battista Venturi
- Conservation of Mass:

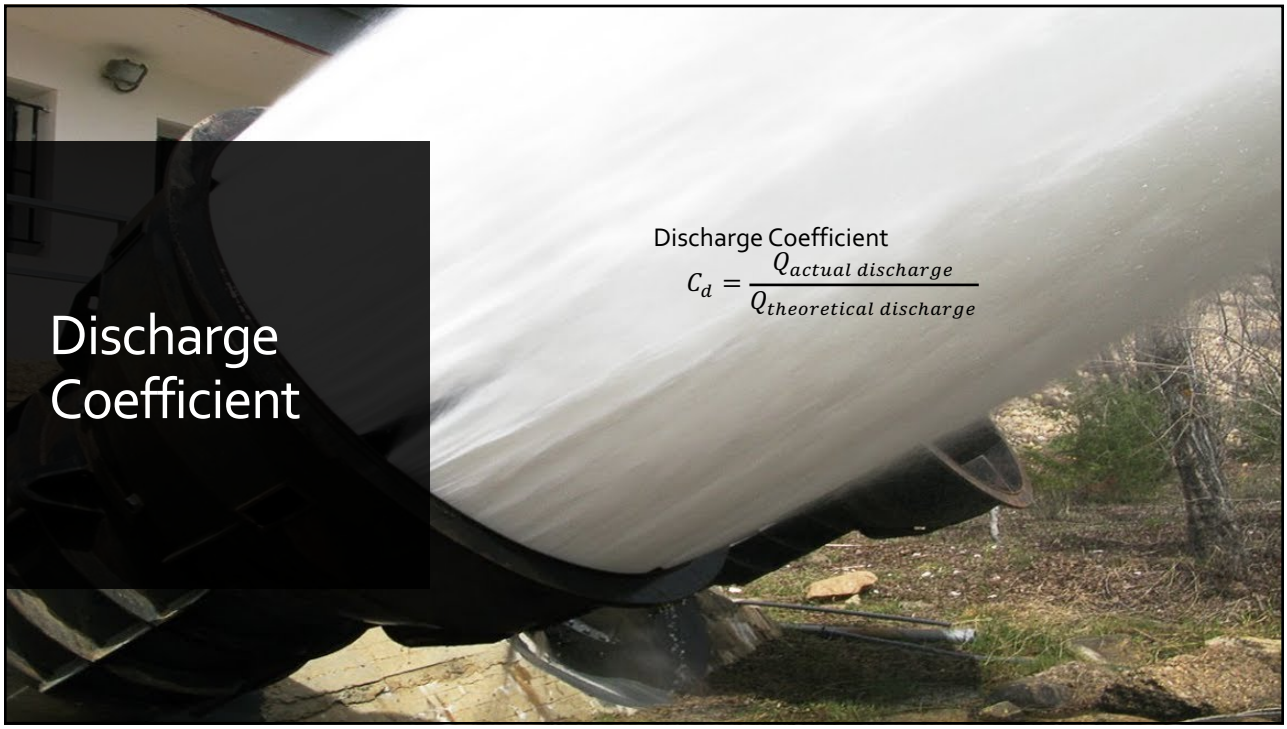
$$\dot{M}_{in} = \dot{M}_{out} \Rightarrow v_{fluid}\, A_{cs}\, \rho_{fluid} = Constant$$

- Bernoulli's Principle:

$$\frac{1}{2}\, \rho_{fluid}\, v_{fluid}^2 + \rho_{fluid}\, g\, h_{fluid} + P_{fluid} = Constant$$

- Rearranging Bernoulli's leads to Venturi's Equation:

$$P_1 - P_2 = \frac{\rho}{2}\,(v_2^2 - \mathrm{v}_1^2)$$



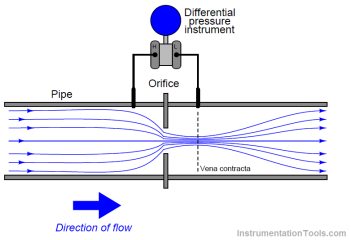
Discharge Coefficient

Discharge Coefficient

$$C_d = \frac{Q_{actual\ discharge}}{Q_{theoretical\ discharge}}$$

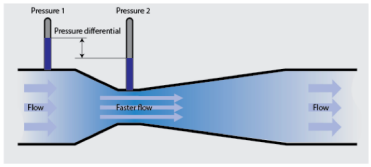
Orifice Flowmeters

- Pros:
  - Cheap
  - Easy to build
  - Compact
  - No moving parts
- Cons:
  - Poor Accuracy
  - Huge Losses
  - Low C_d



Venturi Flowmeters

- Pros:
  - High Accuracy
  - No moving parts
  - Reduced Losses
  - High C_d
- Cons:
  - Expensive
  - Large (Compared to Orifice)



Orifice and Venturi Flowmeter Uses

- In-Line $\dot{Q}$ measurement for any fluid
- Can be used in nearly any type of environment
- Applications include plumbing, automotive carburetors and chemical transport pipelines
- The Fluids Lab!

Questions?

References

- http://info.smithmeter.com/literature/docs/tp02001.pdf
- https://www.emerson.com/en-us/automation/measurement-instrumentation/flow-measurement/about-liquid-turbine-flow-meters
- https://www.drurylandetheatre.com/si-lwgy-sanitary-flow-meter/
- https://www.aopa.org/news-and-media/all-news/2017/july/flight-training-magazine/pitot-tube
- https://www.boldmethod.com/learn-to-fly/systems/what-happens-when-your-pitot-tube-ices-over-airspeed-indicator/
- https://sciencing.com/calculate-steam-velocity-4924192.html