22642 Indian Springs Road, Salinas, CA (831)-455-0418 Dave@TacticalFlowMeter.com

Ultrasonic Sensor principle Simplified by Dave Korpi

See video here

0. Specifications

- Medium: Any acoustically conductive fluid with less than 5% air bubbles or solids
- Pipe size: ¼” to 240”
- Flow rate: 0 - 200 GPM, guessing….
- Temperature: - 20 - 110 ℃
- Transducer material: Aluminum and 304 SS
- Cable length: 8’
- Accuracy: ±1% from 0.15 to 40 f/s (0.05 to 12 m/s)
- Resolution: 0.01 ft/s (0.00025 m/s)
- Response time: 150 ms measuring cycle typical
- Transducer Frequency: 1 MHz
- Clamp-on transducers: encapsulated design IP68
- Enclosure Protection Grade: IP65
- Display LCD Screen
- Power Supply: 24VDC or 86-240 VAC Universal Power Supply
- Output: 4-20mA + 0-10K Hz + Standard ModBus RTU Communication protocol
- Note: For 1 to 5 VDC output, add 250 Ohm resistor to 4 to 20 mA loop.

1. Overview

§1.1 Preface

The wall-mounted type ultrasonic flowmeter, can be used for nearly any liquid from water, sewer water, petrol chemicals, metallurgy, electric power plant coolant flow, irrigation, city water, energy monitoring, the meter can indicate flow velocity, flow rate, total flow for nearly any fluid.


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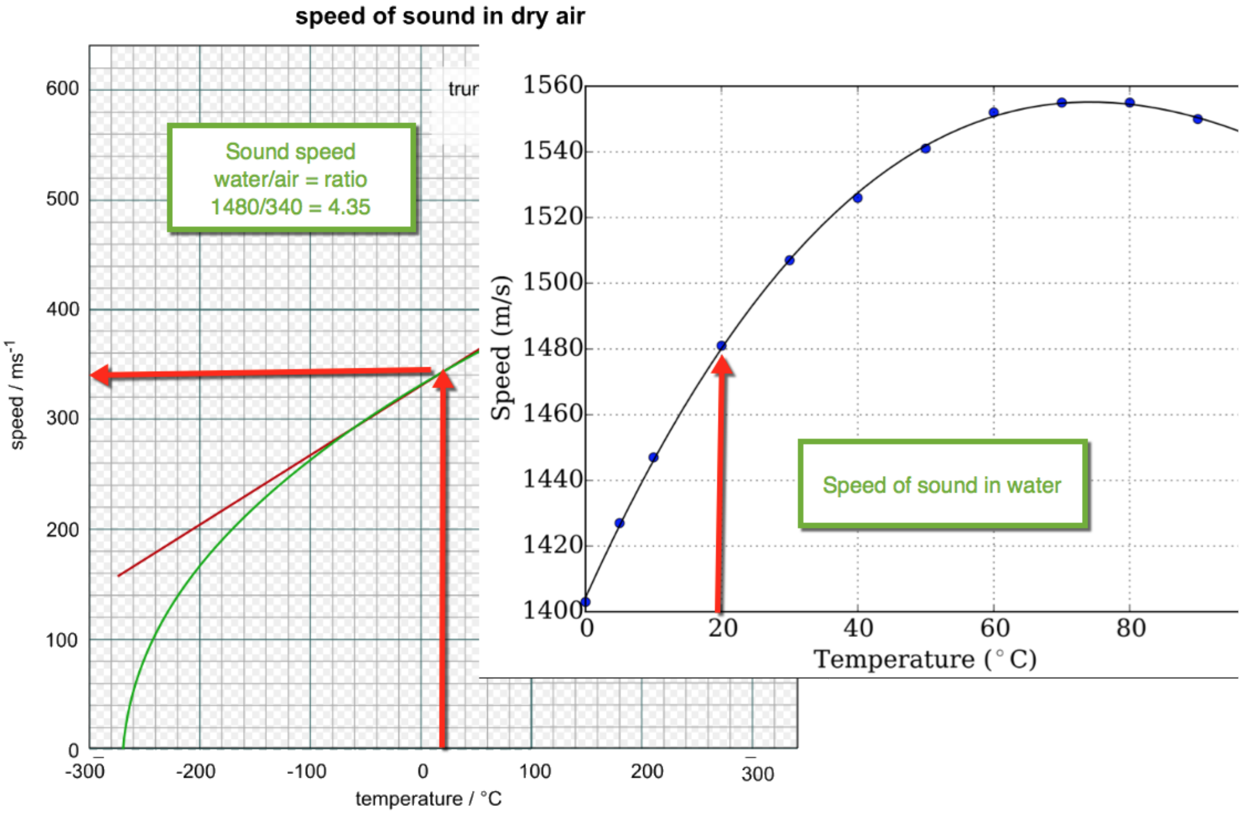
Below we see that the speed of sound in water at 20 C is 4.35 times faster than air at the same temperature. This is why you can not locate the direction of sounds when you are underwater. Your ears are too close, and our brains are too slow to triangulate as we do in air.



§1.2 Principle of Operation

When an ultrasonic beam is transmitted through a flowing liquid, there is a difference between the upstream and downstream transit time that is proportional to the fluid flow velocity. When the fluid is flowing, the reverse transit time is greater than the forward flow transit time. This allows us to measure a time difference and that difference is due to the fluid flow velocity measured across the ultrasonic flow path across a known internal pipe diameter that allows the calculation of Flow from Q = AV where the A is derived from the pipe diameter D.

Variable Names:

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θ: The angle between the ultrasonic beam and the flow.

M: Transit times of the ultrasonic beam.

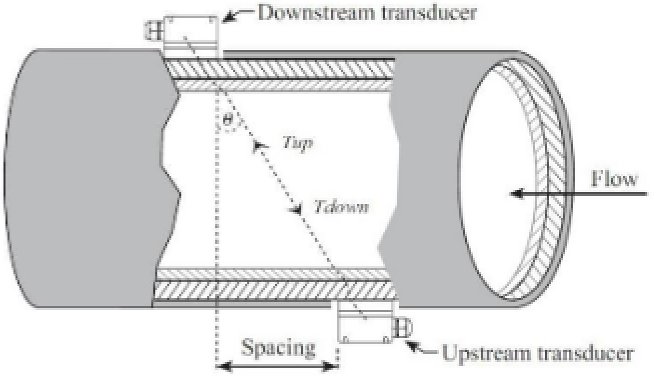
D: The internal diameter of the pipe.

Tup: Transit time in the forward direction.

Tdown: Transit time in the reverse direction.

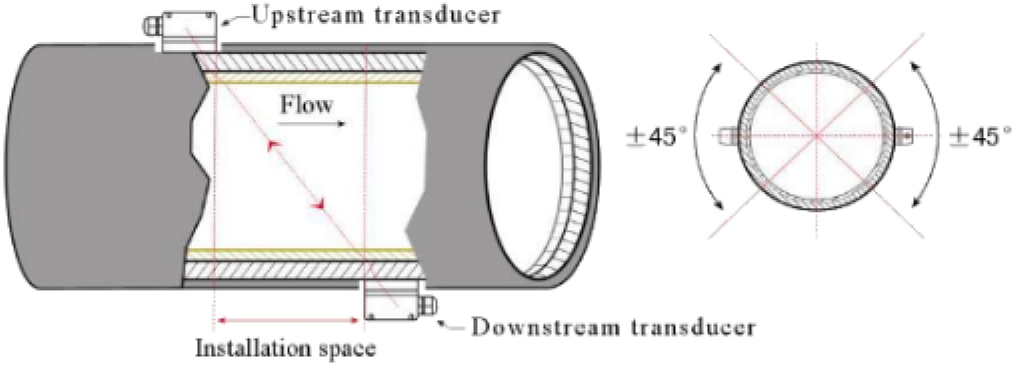
ΔT=Tup –Tdown

$$V = \frac{MD}{\sin 2\theta} \times \frac{\Delta T}{T_{up} \bullet T_{down}}$$

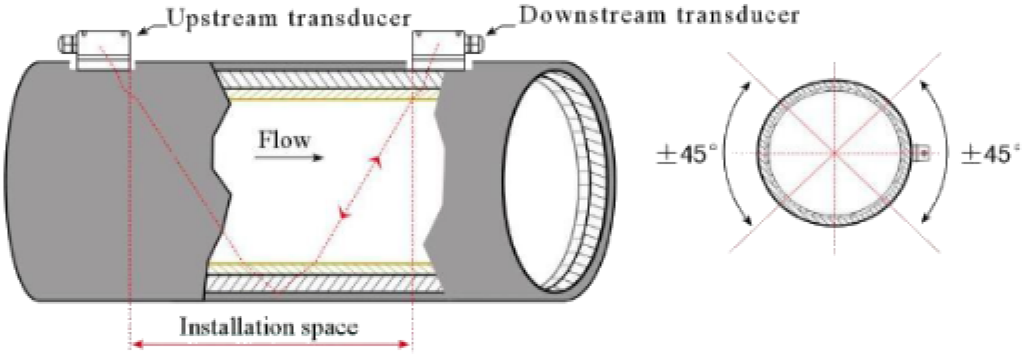


There are two commonly used installation methods, the V method and the Z method

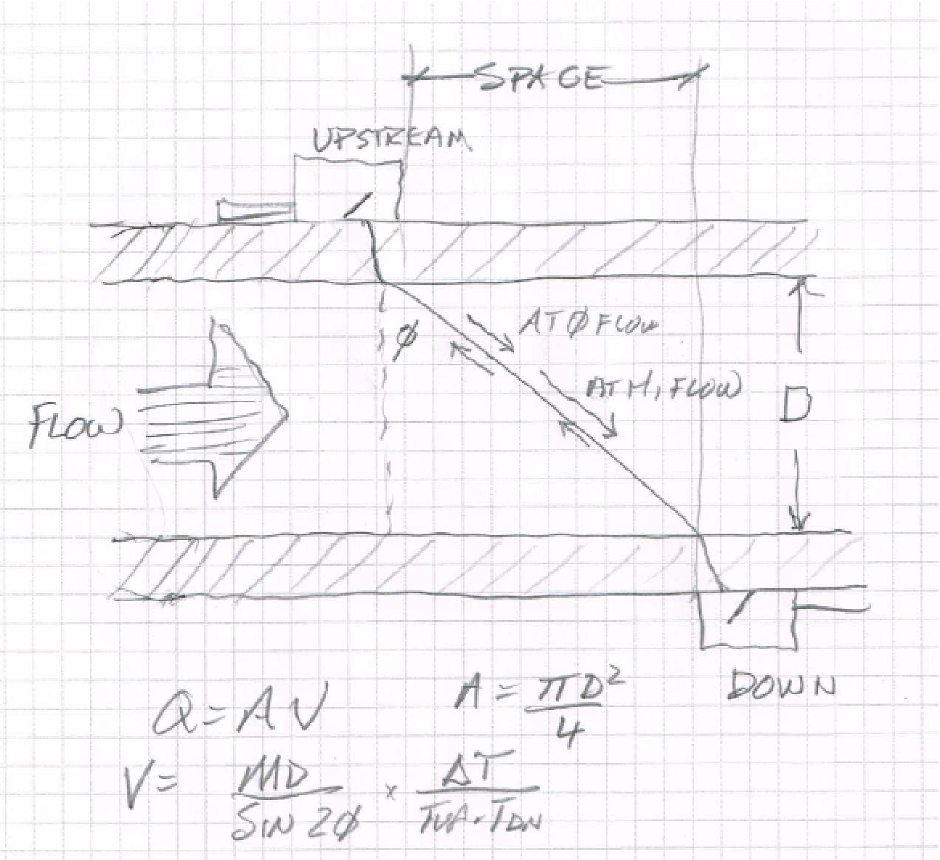
Normaly, V method is utilized for pipe diameters within the range: ½” - 4” or DN15-DN200mm. If using the V method results in a poor signal we suggest using the Z method that is normally utilized for diameters are greater than 8” or DN200mm or when measuring flow in cast iron pipes.



For the V Method use the figure below as a guideline and horizontally align the two transducers. Note the center line is horizontal with the pipe axis line. This method is suitable for pipe diameters in the range of ½” - 16” orDN15mm-DN400mm. This method is considered a reflected mode.



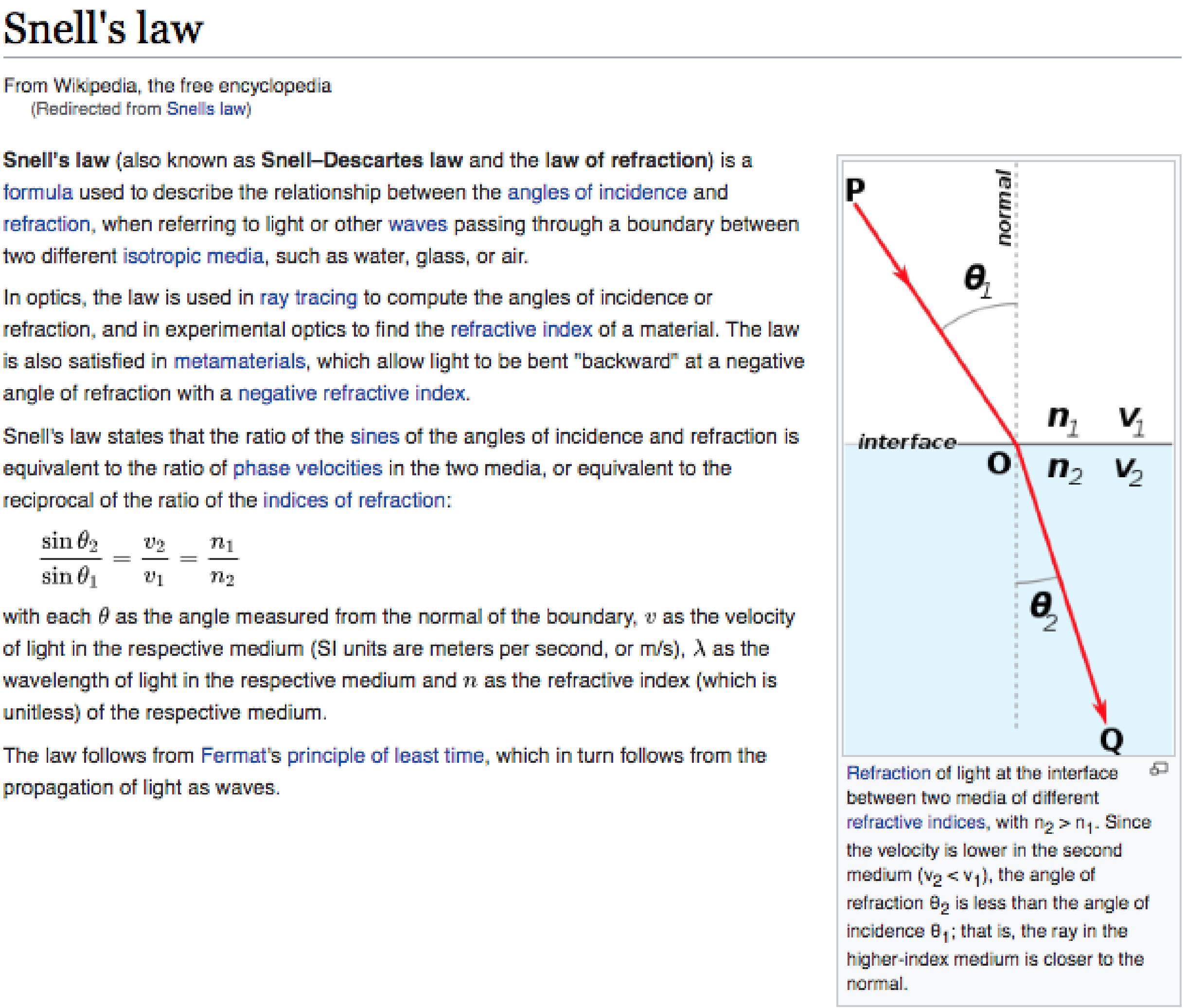
Use the Z method for large pipe diameters and where there may be suspended particulate or scaling. This method is ideal because the transducers dransmit directly to each other without the reflection mode utilized in the V method. This method is known as the single sound path method.



$$Q = AV \qquad A = \frac{\pi D^2}{4}$$

$$V = \frac{MD}{\sin 2\phi} \times \frac{\Delta T}{T_{UP} \cdot T_{DN}}$$

Snell’s Law:



Snell's law

From Wikipedia, the free encyclopedia
(Redirected from Snells law)

Snell's law (also known as **Snell–Descartes law** and the **law of refraction**) is a formula used to describe the relationship between the angles of incidence and refraction, when referring to light or other waves passing through a boundary between two different isotropic media, such as water, glass, or air.

In optics, the law is used in ray tracing to compute the angles of incidence or refraction, and in experimental optics to find the refractive index of a material. The law is also satisfied in metamaterials, which allow light to be bent "backward" at a negative angle of refraction with a negative refractive index.

Snell's law states that the ratio of the sines of the angles of incidence and refraction is equivalent to the ratio of phase velocities in the two media, or equivalent to the reciprocal of the ratio of the indices of refraction:

$$\frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1} = \frac{n_1}{n_2}$$

with each θ as the angle measured from the normal of the boundary, v as the velocity of light in the respective medium (SI units are meters per second, or m/s), λ as the wavelength of light in the respective medium and n as the refractive index (which is unitless) of the respective medium.

The law follows from Fermat's principle of least time, which in turn follows from the propagation of light as waves.

Refraction of light at the interface between two media of different refractive indices, with $n_2 > n_1$. Since the velocity is lower in the second medium ($v_2 < v_1$), the angle of refraction θ_2 is less than the angle of incidence θ_1; that is, the ray in the higher-index medium is closer to the normal.

See video here