How is flow measured?

The simplest method to determine flow in an open channel with free surface is the calculation with a resistance formula, as for example the resistance equation according to the Manning formula.

Necessary parameters are slope, wetted cross-section, wetted perimeter as well as the roughness of the channel. The roughness coefficient is emperically derived and depends on material and age of the channel.

In applications with a stationary uniform flow, it would be sufficient for the measurement to capture only the water level and to use the known parameters to calculate the flow velocity.

Nevertheless, if the roughness of the channel changes in the course of time due to deposits or grease sediments on the walls, this will lead to measurement errors when the variations in roughness are disregarded.

Nowadays, a more modern method is the area velocity method. Here, both water level and flow velocity are determined. When the 3-dimensional flow velocity field is captured only by flow velocity measurements at single points or partial areas, the mean flow velocity has to be calculated in the wetted cross-section.

The higher the amount of measuring points, i.e. the bigger the area of the cross-section in which flow measurements are made, the better the quality of the measurement.

Relations between point or area measurements or between maximum and mean velocity are vulnerable and require a careful calibration at site.

Different technologies can be considered for flow measurements according to the area velocity method.

For measurements in heavily polluted water, beside the inductive measuring procedure and the ultrasonic transit-time procedure, the ultrasonic Doppler as well as the non-contact Radar Doppler are being used.

Ultrasonic-Doppler

The ultrasonic Doppler method makes use of the Doppler effect to determine the flow velocity.

When ultrasonic waves are combined and sent into the flow at a constant sending frequency, the velocity of small particles in the flow changes the frequency of the reflected waves.

The measuring principle assumes that the velocity of the moving particles is approximately the same as the flow velocity.

Nowadays, two types of ultrasonic Doppler methods are applied; the continuous wave Doppler (CW) and the Pulse Wave Doppler (PW).

The methods differ in the construction of the flow velocity sensor, the signal processing, as well as in the information content of the measurements.

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Continuous Wave Doppler (CW)

CW Doppler is the oldest and electronically much more simple of both, in which sound waves are continuously sent and received. One of the main disadvantages is that an exact allocation of the frequency shift is not possible and therefore the allocation of the particle velocity to the place of the particle is not possible, either. Hence, information of the velocity profile is not available. The mean velocity is calculated by means of calibration factors, which have to be determined in time consuming and expensive comparative measurements that are vulnerable to influences like backwater or deposits.

Pulsed-Wave Doppler (PW)

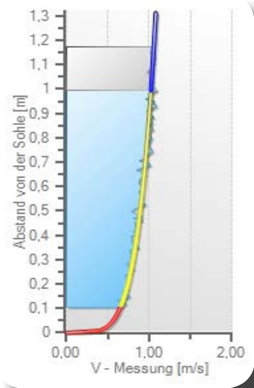
The Pulsed-wave Doppler is a technological enhancement. A special signal evaluation allows for the acquisition of the flow velocity in a certain measurement window (cell). The complete velocity profile along a measuring path can be stored.

Reflections outside of these measuring cells have no disturbing influence on the velocity measurements and can be ignored. With the information of the complete velocity profile, calibration functions which are considerably more stable can be implemented.

HydroVision Spectral-Correlation-Doppler (PSC)

By developing the PSC technology HydroVision managed to improve even the PW method.

When compared against the simple cross-correlation method (determination of specific patterns in the flow) the PSC technology allows for a measurement in considerably **more cells** with a cell size of only a few milimeters and measures the velocity profile with a much higher resolution.



By means of a special correlation technology in signal processing, it is possible to measure flow velocity profiles very close to the sensor (low water level), as well as in big distances to the sensors (high water level). This makes the sensor suitable for both shallow waters and applications with higher water levels.

In contrast to the Spectral-Correlation method, the simple cross-correlation method does not measure velocity until several cm (5-6 cm) away from the sensor. In addition, the maximum distance is limited to as little as 1m due to noise in the medium (weak patterns for higher distances).

Also, in a sensor based on the PSC method, no complex and vulnerable electronic needs to be built in, making it possible to keep the sensor small and less influenced by temperature fluctuations (due to different extension coefficients of sensor housing and build-in electronic).

This is why HydroVision is happy to grant a 3-year warranty on all sensors based on the above facts.

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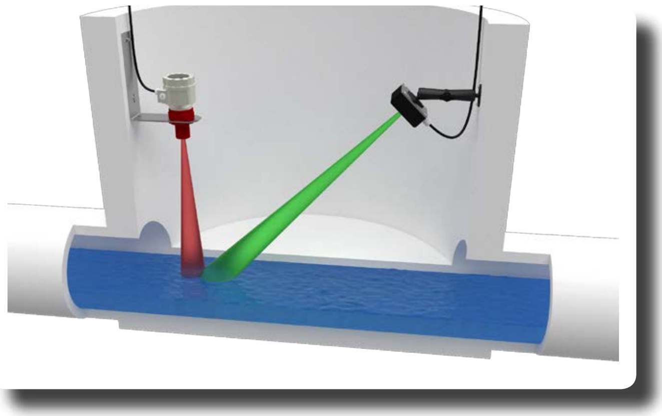
Radar-Doppler

The flow velocity measurement according to the Doppler effect can also be used by means of radar (electro magnetic waves), where the velocity of moving structures at the water surface is measured.

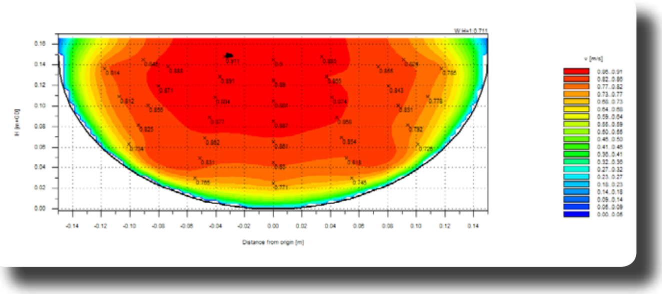
An area is measured, which size depends on the fluctuating distance (fluctuating water level) and the declination angle of the sensor towards the reflecting water surface.



HydroVision has developed a **finite difference algorithm** which calculates the average velocity in the entire cross-section from the measured flow velocity at the water surface.

Extensive calibration measurements are no longer necessary and the measuring result has the desired high accuracy right from the beginning.

Non-contact measurements offer big advantages, especially for applications in aggresive media.



Q-Eye PSC portable

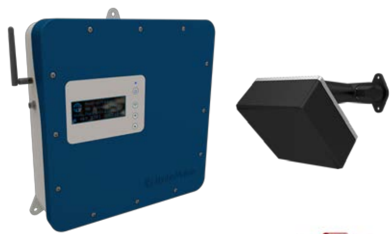
mobile Puls-Doppler system

Q-Eye PSC MT

stationary Puls-Doppler system

Mounting Accessories

standardized mounting kits from Ø 0,1 to 2 m



Q-Eye Radar MT

contact-free system with Radar

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