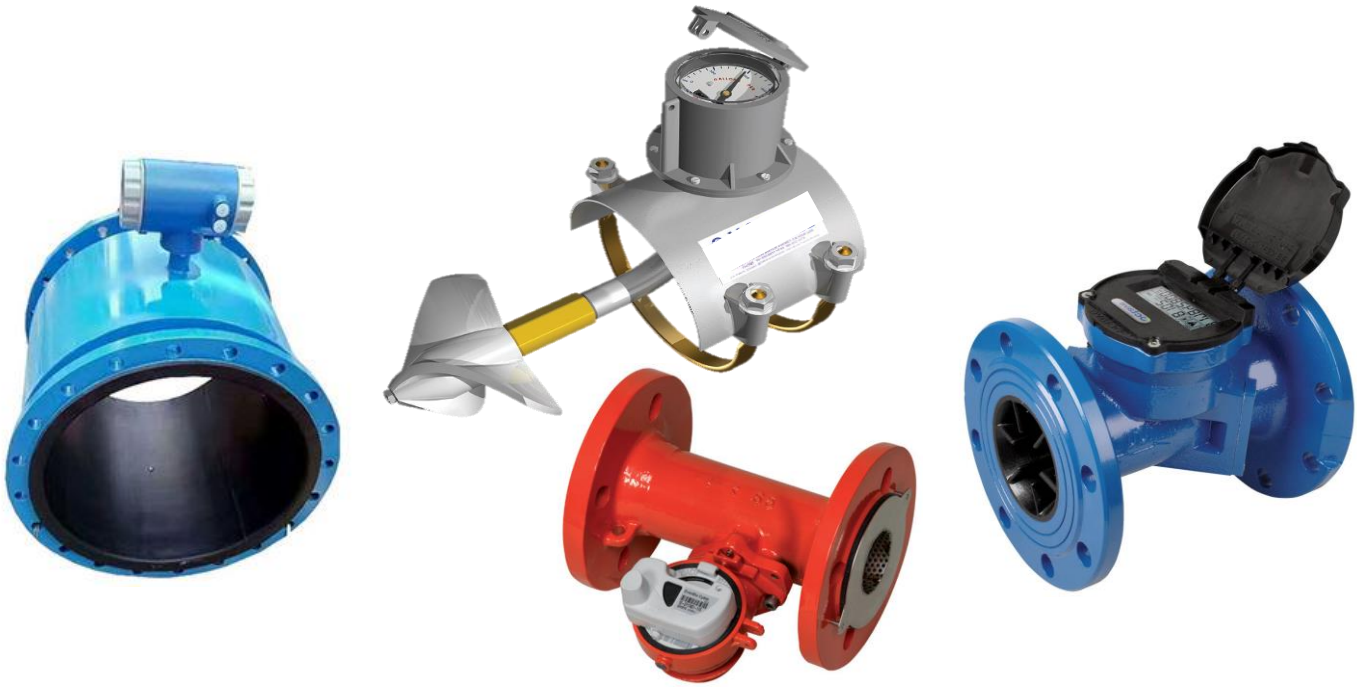
Guidelines
for selecting measuring devices for irrigation water measurement:
Pipe flow



Developed as part of WRC K5/2957//4:

Knowledge exchange to improve implementation of irrigation water measurement/metering at farming and scheme level

2019

INTRODUCTION

Dear Water User

Good measurement and monitoring of water use assist with efficient irrigation planning and management at both scheme and farm level.

To this effect, the Department of Water and Sanitation has published several regulations in terms of section 26 (1) (b) of the National Water Act (no. 36 of 1998) requiring that the use of water from a water resource be monitored, measured and recorded:

- Government Notice 538 of 2016 – Revision of General Authorisation for the taking and storing of water
- Government Notice 131 of 2017 – Regulation requiring that the taking of water for irrigation purposes be measured, recorded and reported.
- Government Notice 141 of 2018 – Regulation instructing Irrigation Boards and Water User Associations to install water measuring devices for water taken for irrigation purposes and to monitor compliance to regulations requiring that the taking of water for irrigation purposes be measured, recorded and reported.

This booklet serves as a brief guide to different types of water meters and how they operate. The layout of the booklet entails a brief description of how each of the metering devices work, how it should be installed, the costs involved, its accuracy, the maintenance required, their advantages and disadvantages and contact details of various suppliers.

We trust that you will find the information useful.

Sarlet Barnard

TABLE OF CONTENTS

CRITICAL FUNCTIONS AND IMPORTANT CONSIDERATIONS

The selection of a measuring device will depend on how the characteristics of the available devices satisfy the requirements set by the responsible authority or as identified by a situation assessment prior to installation. In general, the requirements should ensure that the device is the most affordable solution that satisfies both the functions required by the reason for installation as well as the required standards. The most suitable measuring device depends on the circumstances under which it is to be installed. When you select measuring devices for flow in pipes, consider the following:

- Water quality:
- Physical and chemical impurities in water
- Flow range:
- Minimum and maximum flow rates (l/s) that could occur at the point of measurement
- Pressure loss:
- Will the additional pressure loss (m) influence the system pressure?
- Accuracy:
- Is the device accurate enough to satisfy the needs set by the responsible authority?
- Reliability:
- Is the device known to be used for irrigation water and what is the warranty?
- Installation conditions:
- Indoors/outdoors, lighting strikes, power spikes, submergence etc.
- Data output requirement:
- Electronic/mechanical, cell phone reception
- Power requirement:
- Is electricity required for the meter to operate
- Maintenance, trouble shooting and repair:
- Who will do it; are spares and support easily available?
- Resistance to tampering:
- What is the risk of tampering and is the device resistant to it?

Once all these aspects have been considered, an informed decision can be made in terms of cost by comparing the different type of measurement devices for the specific application.

GENERAL INSTALLATION REQUIREMENTS FOR WATER METERS

- Make sure the pipe where the meter is fitted is completely filled with water.
- Install meter in a low horizontal or slightly rising section of pipe.
- Install the meter in a straight pipe section, without any fittings that can cause disturbances, and with a constant diameter for a length at least 10 times the pipe diameter upstream of the meter and at least 5 times the pipe diameter downstream of the meter.
- If flow varies, install equipment to protect the meter against pressure pulsations and flow surges.
- If impurities in the water are a problem for the selected meter, you can:
  - install a filtration element upstream of the meter (not recommended since the filter may become blocked and will require regular maintenance).
  - replace with a meter that is less sensitive to impurities (recommended).
- Adhere to earthing requirements set by meter manufacturers.
- Install the meter in the correct direction.
- If the meter is installed above ground, support it on both up and downstream sides to minimize the effect of vibration.
- In the case of long downhill pipelines:
  - install a control valve at a distance of 10 pipe diameters upstream of the meter, to stop flow in the if the meter has to be removed.
  - install a drainage plug close to the meter to drain the pipe before removing the meter.
- If the meter is located near a local peak in a pipeline, an air valve is recommended.
- Use galvanized metal or protect the metal against corrosion with suitable paints.
- When cutting or welding near flow meters, stay clear of plastic fittings or components, since they will melt.
- Install an adjustable coupling on one side of the meter to allow for expansion of the pipework, as well as easy removal of the meter.
- Standardise to a specific type of flange so that fittings can be universal and fitted with the flanges of the meter.
- Use gaskets between flanges and bolts torqued correctly to prevent water leaks and unnecessary strain on the pipework.
- Avoid strong electromagnetic fields in the vicinity of the meter that can affect its operation and calibration.
- Install lightning protection.

MECHANICAL METERS

HOW IT WORKS

Mechanical meters have rotor-mounted blades in the form of a vaned rotating element which is driven by the water at a speed proportional to the discharge. The number of rotor revolutions is proportional to the total flow through the meter and monitored by either a gear train or by a magnetic or optical sensor.

***Turbine**:* Horizontal or vertical axially mounted bladed rotor on bearings or bushes mounted concentrically within the flow stream with support struts.

***Impeller*:** The rotating blades are perpendicular to the flow making it less accurate than the turbine meter.

***Propeller**:* A long axle with a propeller mounted on one side and the body of the meter, out of the line of flow, on the other side.

***Proportional*:** Only part of the total flow passes by the measuring element through a venturi which is proportional to the total flow.

Turbine

Impeller

Propeller

Proportional/bypass

INSTALLATION

- Specified in DN; available in pipe sizes of 5 - 800 mm ID.
- Meter size selection should be for maximum flowrate of the application.
  - too high flowrates can cause damage to the meter register.
  - too low flowrates can result in poor accuracy of measurement.
- Ensure the pipe is always filled with water.
- Keep pressure loss through the meter to a minimum (20 - 30 kPa) to prevent cavitation.
- Do not select turbine, propeller or bypass meters if any algae, water grass or gravel passes through the pipe.
- Installation of strainers aren't ideal; they require regular cleaning which increases management cost of the meters.

COST	*ACCURACY*	*MAINTENANCE*
Low capital cost	Relatively low under poor installation conditions. (within ± 10 % in practice) Deteriorate over time	• Prevent the entry of debris into the pipeline; install strainers and clean regularly. • Prevent moisture in the secondary elements or gear trains and rectify if it occurs. • Verify meter performance annually with a clamp-on type ultrasonic meter. • Inspect the measuring element and condition of the housing bi-annually or as recommended by manufacturer.

ADVANTAGES	*DISADVANTAGES*
• No electric power required; can be installed at remote sites. • Available for a wide flow range. • Robust and ease of use.	• Susceptible to blocking by larger physical impurities (not as much impeller). • Inaccurate readings if used outside their recommended ranges. • Difficult to install in existing pipelines (and remove for repairs). • Excessive additional friction loss at smaller diameters than that of the pipe. • Susceptible to submergence if installed in a low part of the pipeline. • May require additional tampering protection.

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WEBSITES: http://www.kbk.co.za/Products/McCROMETERFLOWMETER.aspx
https://www.netafim.co.za
https://www.xylem.com/en-za/

ELECTROMAGNETIC METERS

HOW IT WORKS

Based on Farady's law of induction.

A magnetic field is produced across a cross-section of the pipe, with the water forming the conductor. Two sensing electrodes set at right angles to the magnetic field are used to detect the voltage which is generated across the flowing water. The strength of the magnetic field is directly proportional to the velocity (discharge) in the pipe.

INSTALLATION

- In-line is more accurate.
- Insertion is easier to install and more affordable.
- Minimum flow velocity of 2 - 3 m/s for water containing solids.
- May require a reduction in pipe size causing additional friction loss in the system.
- The meter and the pipeline should be well earthed to protect it against lightning.
- The electricity, data cables and digital display units should be protected against vandalism and sunlight.

COST

- Inline type is relatively expensive, and it requires electricity to record readings.
- Insertion type is more affordable and requires less power, (battery operation is possible).

ACCURACY

- In-line ± 0.5% of reading
- Insertion type ± 2% of reading

MAINTENANCE

- Only minor routine maintenance is necessary.
- Inspect lining, earthing and electrodes annually.
- Perform verification when necessary but at least every 5 years.

In-line

Insertion

ADVANTAGES	***DISADVANTAGES***
• No pressure drop (no flow obstruction in in-line; minor flow obstruction in insertion type) • No moving parts, is relatively insensitive to flow profile changes (in-line type) • Short inlet / outlet sections (5D / 2D) for stable flow • High accuracy • Wide flow range • Robust with minimal routine maintenance • Can be buried (vandalism proof) • Difficult to tamper with, without detection	• Calibration and re-calibration. This requires a portable flowmeter. • A reduction in pipe size for a higher velocity through the meter may result in a reduction in pressure and subsequently less efficient irrigation. • Relatively expensive (in-line type) • Inaccurate at low flow velocities (requires at least 2 m/s in pipe) • Power supply required • Larger sizes are difficult to handle due to weight • Electronic components vulnerable to lightning damage • Sensitive to electromagnetic interference • Repairs require skilled technicians and specialised equipment • Pipeline must be full • chemical coatings, or organic material depositions, especially on the insertion electrodes.

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WEBSITES: http://www.flowmetrix.co.za/
https://www.nz-online.co.za
http://www.lindsayafricagb.com/

ULTRASONIC (ACOUSTIC) METERS

HOW IT WORKS

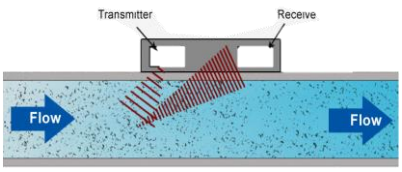
Ultrasonic meters comprise two types i.e. the Doppler and the Transit Time. Ultrasonic signals are transmitted through the wall of the pipe and works on most pipe materials found in the irrigation field, so that no installation equipment, changes to pipe work or disruption of flow is necessary. Portable clamp-on models are commonly used for in-field verification of other installed meters; or temporary measurement of flow at different points in pipe distribution.

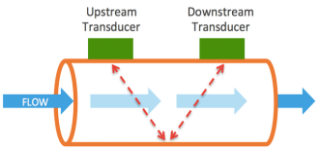
Doppler

The doppler sensor transmits an ultrasonic signal at an angle into the water flowing in the pipe. Some of the signal is reflected to the sensor by suspended solids in the water. The reflected signal has a different frequency than the original one, and the frequency difference (doppler shift) is directly proportional to the velocity of the particles.

Transit Time

The transit time meter comprises two transducers mounted at an angle to the flow and each act as a transmitter and receiver. The distance that the signal travels between the transducers is the path length. The transit time of the signal is measured in both directions over the path length. The flow velocity is directly proportional to the difference in transit time over the path length.





INSTALLATION

- Doppler meters have one transducer - follow manufacturer's guidelines when attaching it to pipe.
- Meters are sensitive to flow disturbances upstream of its location; enough length for a fully developed flow profile is required.
- Do not mount transducers on top of (air accumulation) or directly under (debris deposition) a horizontal pipe.
- Establish and maintain good contact between the transducers and the pipe wall for temporary installations.
- Calculate transducer spacing based on manufacturer guidelines.
- Meters for permanent installations are available in factory fitted flanged housing.
- Install transducers opposite each other to transmit the signal directly across the pipe diameter or next to each other for signals to reflect off the inside pipe wall.

COST	*ACCURACY*	*MAINTENANCE*
▪ Doppler meters are quite high ▪ Permanent transit time meters, similar to electromagnetic meters.	▪ Doppler meters ± 10% of reading ▪ Transit time meters: portable ± 2% and permanent 0.5 - 1% of reading.	▪ No routine maintenance is required ▪ Periodic replacement of wires and batteries ▪ Occasional upgrade of supporting software

ADVANTAGES	*DISADVANTAGES*
▪ No contact between the transducers and the water required. ▪ Easy installation for temporary use. ▪ Wide range of flows can be measured with the same meter. ▪ Non-intrusive; no moving parts; measure at high accuracy. ▪ No additional head loss in the pipeline. ▪ One size meter for all pipe sizes. ▪ Portable models are generally robust. ▪ Wide range of flow data is captured ▪ Empty pipe can be detected.	▪ Low accuracy of the Doppler meter (+-10%) ▪ The Doppler meter requires minimum size and concentrations of particles in the water being measured. ▪ Very sensitive to flow profile variations. ▪ Permanent models require external power for extended periods ▪ High cost, especially good quality transit time meters. ▪ Repairs require skilled technical staff with specialised equipment.

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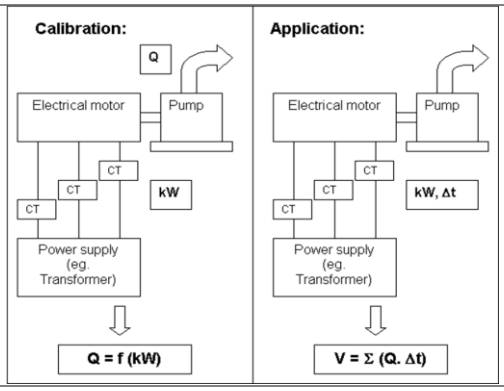
WEBSITES: https://arad.co.il/product/octave/
https://www.netafim.co.za/
http://www.flowmetrix.co.za/

ELECTRIC POWER SUPPLY MEASUREMENT

HOW IT WORKS

An electric power supply measurement entails a combined energy and water meter that is specifically developed for raw water metering and where pumping is involved. The method of measurement assumes that the combined pump and motor efficiency is constant for a specific flowrate of the pump and doesn't change significantly over time. Several electric variables are measured to establish the flow rate and the cumulative flow of the water. This meter only measures the power inputs to the specific pump unit/set and is not in direct contact with the water.



INSTALLATION

The installation of the meter and its calibration on site is simple and doesn't involve any pipe cutting, but only electric power supply connections. It is installed in the existing box which houses the electric switchgear directly from the power supply and without wiring to the pump. Calibration of the pump should be done by means of an accurate portable flow meter. A calibrated container can also be used to do the calibration volumetrically.

COST	*ACCURACY*	*MAINTENANCE*
The cost is lower than the cost for mechanical meters and don't change as the delivery pipe size changes.	The accuracy of these meters is higher than that of mechanical meters	Not much maintenance is required since there aren't many moving parts in these meters. They are quite vulnerable to lightning and therefore ongoing attention needs to be given to the proper functioning of the surge breakers. Re-calibration of this meter type is necessary every few years considering the wear and tear on the pump and electric motor.

ADVANTAGES	*DISADVANTAGES*
• Low price (less than mechanical meter) • No moving parts for excessive maintenance or intruding parts in the water • Easy to install • No head-loss due to an in-line meter • Very low maintenance required • Features that can protect the electric motor, pump and main lines • Results from calibration will indicate the condition of the pump system	• Calibration and re-calibration every two years or as required. This requires a portable flowmeter.

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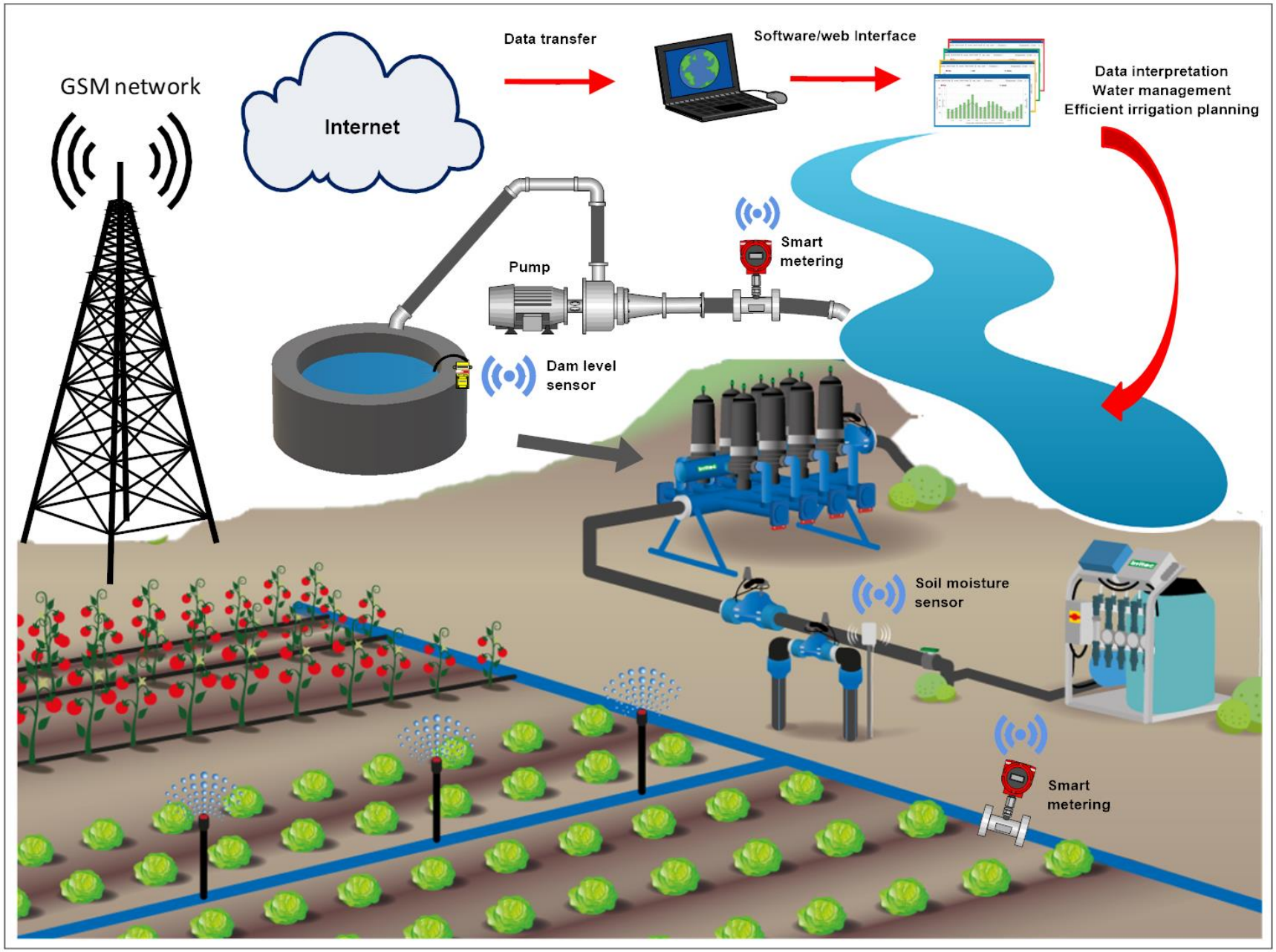
TABLE 1: SUMMARY OF MEASUREMENT DEVICES FOR PIPE FLOW

Method	Standard: volumetric data output (m^3)	Standard: flow rate data output (m^3/h)	Hydraulic sensitivity to installation conditions	Standard: external power requirement	Relative Accuracy	Sensitivity to dirty water	Additional pressure loss in system (m)	Continuous data recording possible	Typical cost of standard unit (excl. VAT)
Turbine	Yes	No	High	No	Moderate	High	Low	Yes*	R7 500 – R34 000 (100 – 250mm) Incl. electronic output
Impeller	Yes	No	High	No	Moderate	Moderate	Low	Yes*	R3 200- R17300 (100 – 250mm) Incl. electronic output
Propeller	Yes	No	High	No	Moderate	High	Low	Yes*	R14 000 – R34 000 (100 - 1200mm) R6 000 for cell phone software
Bypass	Yes	No	High	No	Moderate/Low	High	Moderate	Yes*	-
Electromagnetic (inline)	Yes	Yes	Moderate	Yes	High	Low	None/Low	Yes*	R40 000 - R65 000 (100 -300mm) incl. installation, annual hosting fee and sim
Electromagnetic (insert)	Yes	Yes	High	Yes	Moderate	Moderate/Low	None/Low	Yes*	-
Acoustic doppler	Yes	Yes	High	Yes	High	Low	None	Yes**	-
Acoustic Transit Time	Yes	Yes	High	Yes	High	Low	None	Yes**	R21 000 – R91 000 (100 - 300mm) (incl. adapter output and power supply)
Electric power	Yes	Yes		No	Moderate/High	Low	None	Yes*	R19 500 (incl. installation)

*Additional hardware sometimes required

**Additional hardware always required

FIGURE 1: DATA MANAGEMENT, MONITORING AND CONTROL

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